TECHNICAL MEMORANDUM

# AN ATLAS OF EASTERN BROWARD COUNTY SURFACE WATER MANAGEMENT BASINS

By

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Water Resources Division
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# AN ATLAS OF EASTERN BROWARD COUNTY SURFACE WATER MANAGEMENT BASINS

## EXECUTIVE SUMMARY

This atlas contains information about the surface water management basins in Broward County, Florida. The South Florida Water Management District (District) and the U.S. Army Corps of Engineers (COE) have primary authority over water management in these basins. The District has sponsored publication of this atlas so that up-to-date non-technical descriptions of the surface water management basins in Broward County are available to District personnel, to local governments in Broward County, and to other interested persons. By text, maps, and tables of information, the basins are defined and located within the county, and those canals, levees, and control structures within each basin and under the management of the District or the COE are located within the basin and are described and discussed with regard to their operation and management.

The surface water management basins of eastern Broward County, Florida, were first delineated in the 1950s by the COE in their General Design Memorandum (GDM) for the Central and Southern Florida Flood Control Project (Project). Based on the hydrology of the basins, the COE designed and constructed a system of canals, levees, and control structures to provide flood protection for southern and central Florida. The Project is dynamic with new works being constructed and old ones being modified to meet the changing needs of southern Florida. Most of the works constructed under the Project are now under the management of the District.

Nine basins are described: the Hillsboro Canal, C-14, Pompano, C-13, C-12, North New River Canal, C-11, C-10, and C-9. These basins are located in the eastern half of Broward County. Water Conservation Areas 2A, 2B, 3A, and 3B which occupy the western half of the county are included in a separate atlas.

The Project canals in Broward County serve a variety of functions. The primary function of all the canals is to provide flood protection for the basins in which they occur. Secondary uses of the canals include land drainage for agriculture and urban or residential development, and regulation of groundwater table elevations to prevent saltwater intrusion into local groundwater. Many of the canals are used to supply water for irrigation and to recharge the wellfields of local municipalities. Three canals, the Hillsboro Canal, C-14, and the North New River Canal, are used to discharge excess water from the Water Conservation Areas to tidewater.

The Project control structures in Broward County regulate the flow of water in the canals. In general they are used to discharge excess water from the basins during flooding and to maintain minimum water levels in the canals during drought periods. Some structures are usually closed to prevent water from passing from one basin to another, but can be opened to supply water from one basin or canal to another as necessary. The coastal structures have the additional function of preventing saltwater from a tidal or storm surge from entering those canals discharging to tidewater.

A bibliography is included with the atlas. It lists publications concerning hydrology and hydraulics, water use, water quality, and land use in Broward County. For the reader unfamiliar with some of the concepts and words used in these descriptions, the appendices contain basic hydrologic and hydraulic concepts, and a glossary of terms.

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## ABSTRACT

An atlas of the surface water management basins in eastern Broward County, Florida, is presented. Nine basins are described by text, maps, and tables of information. The basins are defined and located within the county, and the canals, levees, and control structures within each basin are located and are described and discussed with regard to their operation and management. Description and discussion of the canals, levees, and control structures in the basins are limited to those works constructed for the Central and Southern Flood Control District.



## ACKNOWLEDGEMENTS

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# AN ATLAS OF EASTERN BROWARD COUNTY SURFACE WATER MANAGEMENT BASINS

## INTRODUCTION

This atlas contains information about the surface water management basins in Broward County, Florida. The South Florida Water Management District (District) and the U.S. Army Corps of Engineers (COE) have primary authority over water management in these basins. The District has sponsored publication of this atlas so that up-to-date non-technical descriptions of the surface water management basins in Broward County are available to District personnel, to local governments in Broward County, and to other interested persons. By text, maps, and tables of information, the basins are defined and located within the county, and those canals, levees, and control structures within each basin and under the management of the District or the COE are located within the basin and are described and discussed with regard to their operation and management.

The surface water management basins of eastern Broward County were first delineated in the 1950's by the COE in their General Design Memorandum (GDM) for the Central and Southern Florida Flood Control Project (Project). Presented in the GDM were the COE's analysis of the hydrology of each basin and an assessment of the flood risk for a storm of specified intensity and duration. Based on the hydrology of the basins, the COE designed a system of canals, levees, and control structures to provide some desired level of flood protection for each basin. Designs of these works were presented in the GDM and in the Detailed Design Memorandum for the Project. Most of the works constructed under the Project are now under the management of the District.

The Project is dynamic. As the population in South Florida has grown, and as land use and water demands have changed, the Project has evolved in response to these changes. Some parts of the original Project were never built, other parts have been rebuilt or modified, and as the need has arisen, new structures have been designed and constructed. In some cases, the basins themselves have been redefined. As the COE can not always participate in construction of new works, the District has occasionally assumed responsibility for design and construction of additions or modifications to the Project.

This atlas describes the nine surface water management basins in eastern Broward County, Florida, and the Project works associated with each. An atlas describing the Water Conservation Areas which occupy western Broward County is contained in a separate memorandum.

Following the basin descriptions is a bibliography of publications related to the surface water management basins in Broward County. A variety of subjects are included: hydrology, hydraulics of canals and structures, water use, water quality, and land use. Included under hydrology and hydraulics are publications describing various statistical and mathematical models used by the District to predict rainfall, runoff, and canal flow.

Although the basin descriptions are not technical, the reader unfamiliar with the hydrology of lands within the county and with basic water resources engineering may find some words and concepts unfamiliar. Where this is the case,

the reader is referred to the appendices. In Appendix 1, is **BASIC CONCEPTS**, which discusses the important concepts the reader should be familiar with to understand the basin descriptions. In Appendix 2 is a glossary of terms, abbreviations, and acronyms used in these descriptions. Also defined in the glossary are the District's designations for the various Project and District works: canals, levees, and control structures.

**Using the Basin Descriptions**

Surface water management basins (hereafter drainage basins) in Broward County are identified by the same designation as the major Project canal located in that basin. For example, C-11 is a canal draining 104 square miles in southern Broward County. The drainage basin, therefore, is the C-11 basin. In most cases, the canal also has a common name by which it is known. For example, C-11 is know as the South New River Canal. The common name is given parenthetically in the chapter titles following the Project designation for the canal. A few Project canals in Broward County do not have a Project designation. In these cases, the canals are referenced by name only.

The descriptions of the drainage basins in this atlas have been arranged by geographic location. They are presented as they occur from north to south in the county, beginning with the Hillsboro Canal basin and ending with the C-9 basin. All of the basins are shown on Figure 1. Map A (folded and placed in the pocket of the flyleaf) is a large map showing the basin boundary, canals, levees, and control structures relative to local roads and landmarks. This map should be referenced to precisely locate basin boundaries and District and Project works within the county.

Each description contains three parts. The first part is a written discussion of the basin and is divided into two sections. The first section, **Description of the Basin**, provides a general description of the basin and its Project and District works: the drainage area; the general location of the basin within the county; the purpose of and general operation of canals in the basin; the alignment of and direction of water flow in these canals; the location of inlets and outlets to the canals; and the location, purpose, and operation of structures controlling flow in the canals. The second section, **Comments on Design and Historic Operation**, provides commentary on a variety of topics related to the basin: the design storm (see **Design Storm** under **BASIC CONCEPTS**); significant changes to the basin and its works (e.g., urban development or enlargement of a canal) since the GDM was written , particularly with regard to any changes in flood protection for the basin; and proposals under consideration to redefine the basin or to modify any canals or control structures.

The second part of each basin description is a set of two maps. The first map locates the basin relative to other basins in Broward County. The second map is a schematic drawing of the basin and its canals and control structures. It is intended that these maps should be used in conjunction with the written descriptions to understand the layout and operation of canals and structures in the basin. Major roads and landmarks are included on the schematic maps to help the reader locate the basin within the county. Precise location of canals or structures within the basin can be obtained by reference to Map A.

The third part of each basin description is a table presenting information about Project and District control structures (see **Control Structures** under **BASIC CONCEPTS**) located in the basin. The tables provide a physical description of each structure: type of structure, method of controlling water flow, and pertinent

dimensions or elevations. Where a structure has been designed to pass a specified discharge under specified conditions of upstream and downstream water levels, this information is included as the design discharge, design headwater stage, and design tail water stage, respectively. The specified discharge is generally the flood discharge expected to pass the structure for the design storm (see **Design Storm** under **BASIC CONCEPTS**). In some cases, however, the design discharges may refer to water passed through the structure to supply downstream users or to maintain a specified water level in a canal downstream. If a structure was designed to be used to maintain a specified upstream water level under normal non-flooding conditions, this information is included as the optimum headwater stage. Peak water levels upstream and downstream of the structures, and peak discharges through the structures, are also given for those structures where this information has been recorded. Other information about the structures may be cited as relevant.

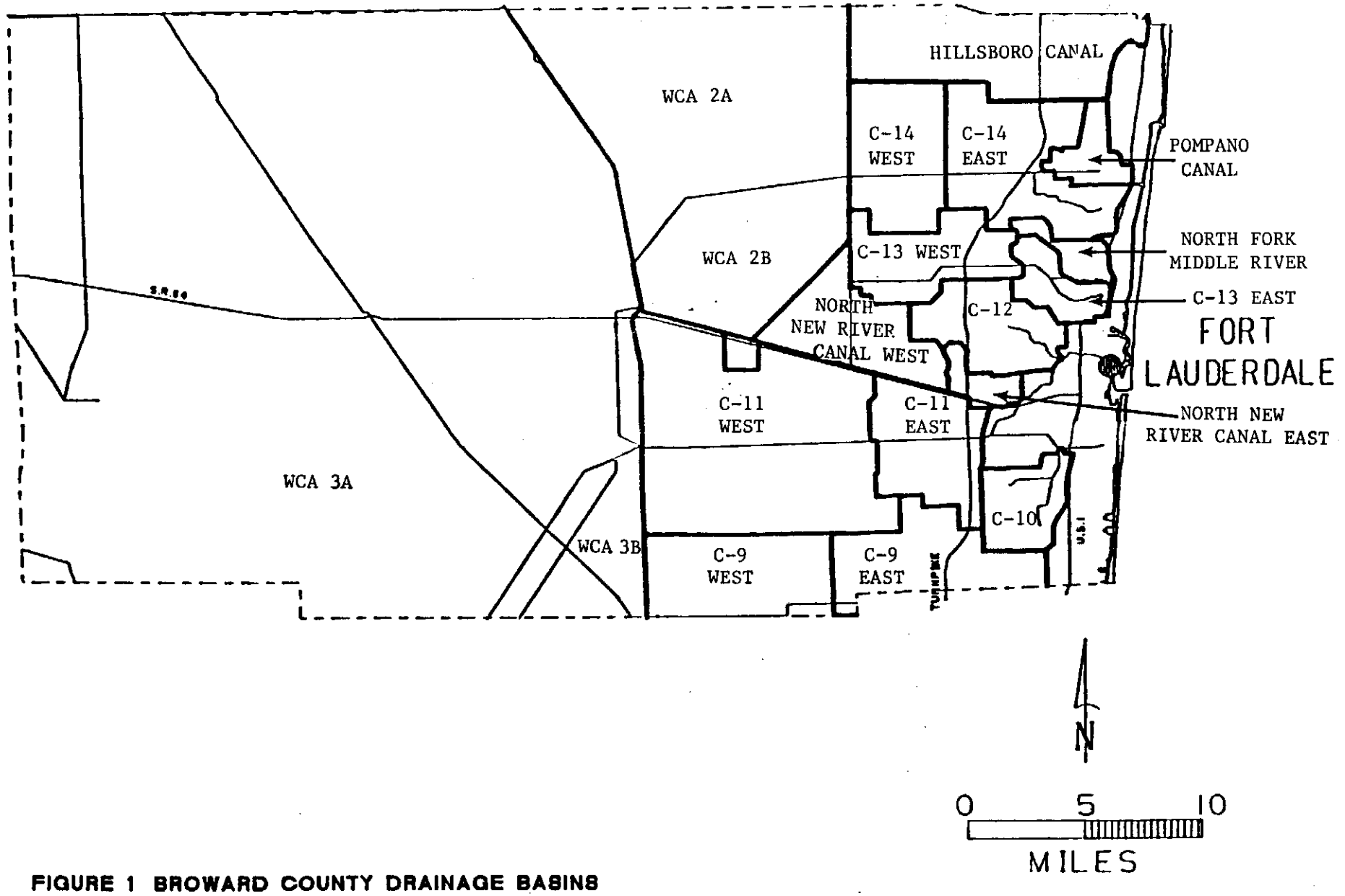



**FIGURE 1 BROWARD COUNTY DRAINAGE BASINS**

## HILLSBORO CANAL BASIN

### Description of the Basin

The Hillsboro Canal basin has an area of approximately 102 square miles and is located in northeastern Broward County (40 square miles, Figure 2) and southeastern Palm Beach County (62 square miles). The basin boundary in Broward County relative to local roads and landmarks is shown on Map A. A schematic map showing the basin boundary, canals, and control structures is given in Figure 3.

The Project canals and control structures in the Hillsboro Canal basin have five functions: (1) to provide flood protection and drainage for the basin, (2) to supply water to the basin during periods of low natural flow, (3) to convey excess water from Water Conservation Area (WCA) 1 to tidewater, (4) to intercept and control seepage from WCA 2A, and (5) to maintain a groundwater surface elevation west of Deerfield Lock adequate to prevent saltwater intrusion into local groundwater. Excess water in the basin is discharged to tidewater by way of the Hillsboro Canal and Deerfield Lock. Excess water in WCA 1 is discharged to the Hillsboro Canal by way of S-39 and subsequently to tidewater by way of Deerfield Lock. Deerfield Lock also regulates water surface elevations in the Hillsboro Canal. Water supply to the basin is from WCA 1 by way of S-39, from WCA 2A by way of seepage to the L-36 borrow canal, and from local rainfall. The seepage rate to the L-36 borrow canal is regulated by the stage held in the canal by S-39A and S-38B.

There are two Project canals in the Hillsboro Canal basin: the Hillsboro Canal and the section of the L-36 borrow canal between the Hillsboro Canal and S-38B.

The Hillsboro Canal connects Lake Okeechobee to the Atlantic Ocean. It enters the basin through S-39 at the intersection of L-36 and L-40. Within the Hillsboro Canal basin, the Hillsboro Canal is aligned parallel to and just north of State Road 827 west of State Road 7 and parallel to and one-half mile north of State Road 810 east of State Road 7. Direction of flow in the canal is normally to the east with discharge to the Intracoastal Waterway just west of the intersection of A1A and State Road 810.

The L-36 borrow canal is aligned north-south along the western boundary of the basin and south of the Hillsboro Canal. The canal intercepts seepage from WCA 2A and is tributary to the Hillsboro Canal. Direction of flow in the canal is to the north to the Hillsboro Canal.

There are four Project control structures regulating flow in the Hillsboro Canal basin: S-38B, S-39, S-39A, and Deerfield Locks (G-56). Design criteria for these structures are given in Table 1.

S-38B is a gated culvert located in the alignment of the L-36 borrow canal just north of Wiles Road at the North Springs Improvement District pump station. The structure is always closed and acts as a divide between the Hillsboro Canal basin and the C-14 basin. The pump station discharges up to 110 cfs of water to either side of S-38B. This water is drainage from the southeast corner of the Hillsboro Canal basin.

S-39 is a gated spillway located in the alignment of the Hillsboro Canal at the intersection of L-39 and L-40. This structure regulates discharges from WCA 1 to the

Hillsboro Canal basin. During normal operation S-39 is opened to supply water to the Hillsboro Canal basin as required to maintain the optimum stage at Deerfield Lock. When WCA 1 is over schedule the structure may be opened to discharge excess water in the WCA to tidewater, by way of the Hillsboro Canal, provided two conditions are met: (1) the water is not needed in WCA 2 or WCA 3 and (2) the Hillsboro Canal is not flowing to capacity (i.e., the tailwater stage at S-39 does not exceed 9.0 ft NGVD).

S-39A is a gated culvert located in the alignment in the L-36 borrow canal just south of the Hillsboro Canal. Together with S-38B this structure controls the seepage rate from WCA 2A to the L-36 borrow canal by regulating the water level in the borrow canal. Normally a stage of 7.0 to 7.5 ft NGVD is maintained in the canal. Runoff, pumped drainage, and seepage to the canal are discharged to the Hillsboro Canal by S-39A.

Deerfield Lock (G-56) is a flashboard controlled five-bay spillway and lock structure. A gated spillway has been constructed within the lock. Deerfield Lock is located in the alignment of the Hillsboro Canal about three-quarters of a mile west of I-95. It controls water surface elevations in the upper reach of the Hillsboro Canal, and it controls discharges to tidewater. In so far as is possible the headwater stage at Deerfield Lock is maintained at 7.7 ft NGVD. This is usually adequate to prevent saltwater intrusion into local groundwater.

**Comments on Design and Historic Operation**

There is no design storm for the Hillsboro Canal. It was built prior to the Project. The District assumed responsibility for the canal and Deerfield Lock from the Everglades Drainage District.

The Hillsboro Canal above Deerfield Lock will pass approximately 1600 cfs without any flooding occurring in the basin. This provides flood protection of approximately three-quarters of an inch of runoff per day; however, allowable runoff into the canal above Deerfield Lock is 1.3 inches of runoff per day (35 cfs per square mile). The total allowable inflow to the canal upstream of Deerfield Lock varies from 2500 to 2700 cfs depending on the drainage area assumed. A hydraulic analysis made in 1974 indicated that if all culverts and pumps discharging into the canal were operated at the allowable runoff discharge, the tailwater stage at S-39 would be approximately 11 ft NGVD. Stages above 9 ft NGVD cause flooding in pasturelands in the southwestern portion of the basin.

To pass the allowable discharge at a stage no higher than 9.0 ft NGVD would require enlarging the Hillsboro Canal from Powerline Road to the west end at S-39. It would also require a new structure (to replace the spillway at Deerfield Lock) capable of passing approximately 3000 cfs at a difference between headwater and tailwater stages of 0.5 feet.

Most inflows to the Hillsboro Canal are from Lake Worth Drainage District canals in Palm Beach County. Because some of the north-south flowing LWDD canals do not have divide structures between the Hillsboro Canal basin and the C-15 basin (nor between the C-15 basin and the C-16 basin), some interbasin transfer of water may occur. This is especially true in the western portions of the C-15 and C-16 basins. Land in the C-15 and C-16 basins between L-40 and the Florida Turnpike may, under some conditions, drain to the Hillsboro Canal by way of LWDD canal E-1.

The stage held in the LWDD canals determines to some extent whether runoff in the basin enters the Hillsboro Canal upstream or downstream of Deerfield Lock. The drainage area upstream of Deerfield Lock may vary by as much as several square miles as the stages in the LWDD canals, especially E-3, vary. E-3 flows to the south one-half mile to the west of and parallel to Military Trail. It enters the Hillsboro Canal just downstream of Deerfield Lock. LWDD typically operates E-3 at a stage of 10 ft NGVD. At this stage, E-3 drains lands as far west as the Florida Turnpike, subtracting considerably from land that would otherwise drain to the upstream side of Deerfield Lock.

During severe storms the Hillsboro Canal develops flows to the east and to the west. The westward flow usually starts at U. S. Highway 441 and moves west to LWDD canal E1/2W approximately three miles west of U. S. Highway 441. The westward flow has a duration of 36 to 48 hours and causes flooding of pasturelands in the southwestern portion of the basin. The peak stage of the westward flow probably occurs one-half to three-quarters of a mile west of U. S. Highway 441. Owners of new developments in the southwestern portion of the basin are required to hold all of the runoff from their property for 48 hours. If the tailwater stage at S-39 exceeds 12.5 ft NGVD, the developers must also accept inflows of water from outside their property and hold it in their reservoirs.

Peak discharges and headwater stages in the basin occurred during the April 25, 1979 storm. The peak discharge at Deerfield Lock was 3700 cfs with an average flow for the day of 3030 cfs. Discharges above 3000 cfs cause flooding in the Boca Raton area and in the area west of U. S. Highway 441. The peak headwater stage at Deerfield Lock was 10.86 ft NGVD with an average for the day of 8.79 ft NGVD. The average tailwater stage on April 25 was 5.51 ft NGVD, and on April 26, it was 6.95 ft NGVD.

Peak tailwater stages occurred during the October 15, 1965 storm. Peak stage at the west end of the Hillsboro Canal at S-39 was 12.39 ft NGVD. At Deerfield Lock, the peak tailwater stage was 9.2 ft NGVD.

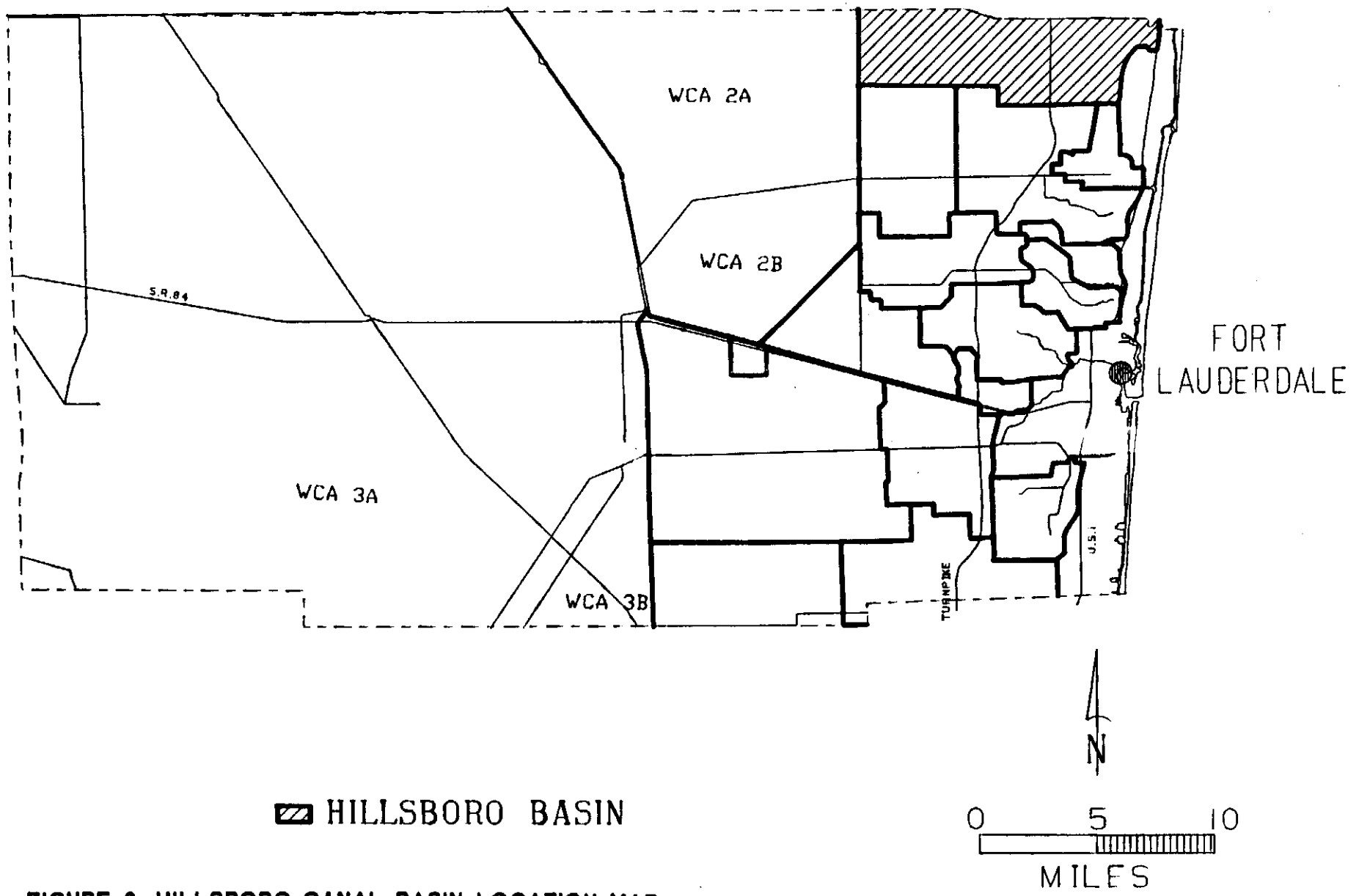



**FIGURE 2 HILLSBORO CANAL BASIN LOCATION MAP**

# HILLSBORO CANAL BASIN

## 65,600 ACRES

## 25,700 ACRES BROWARD

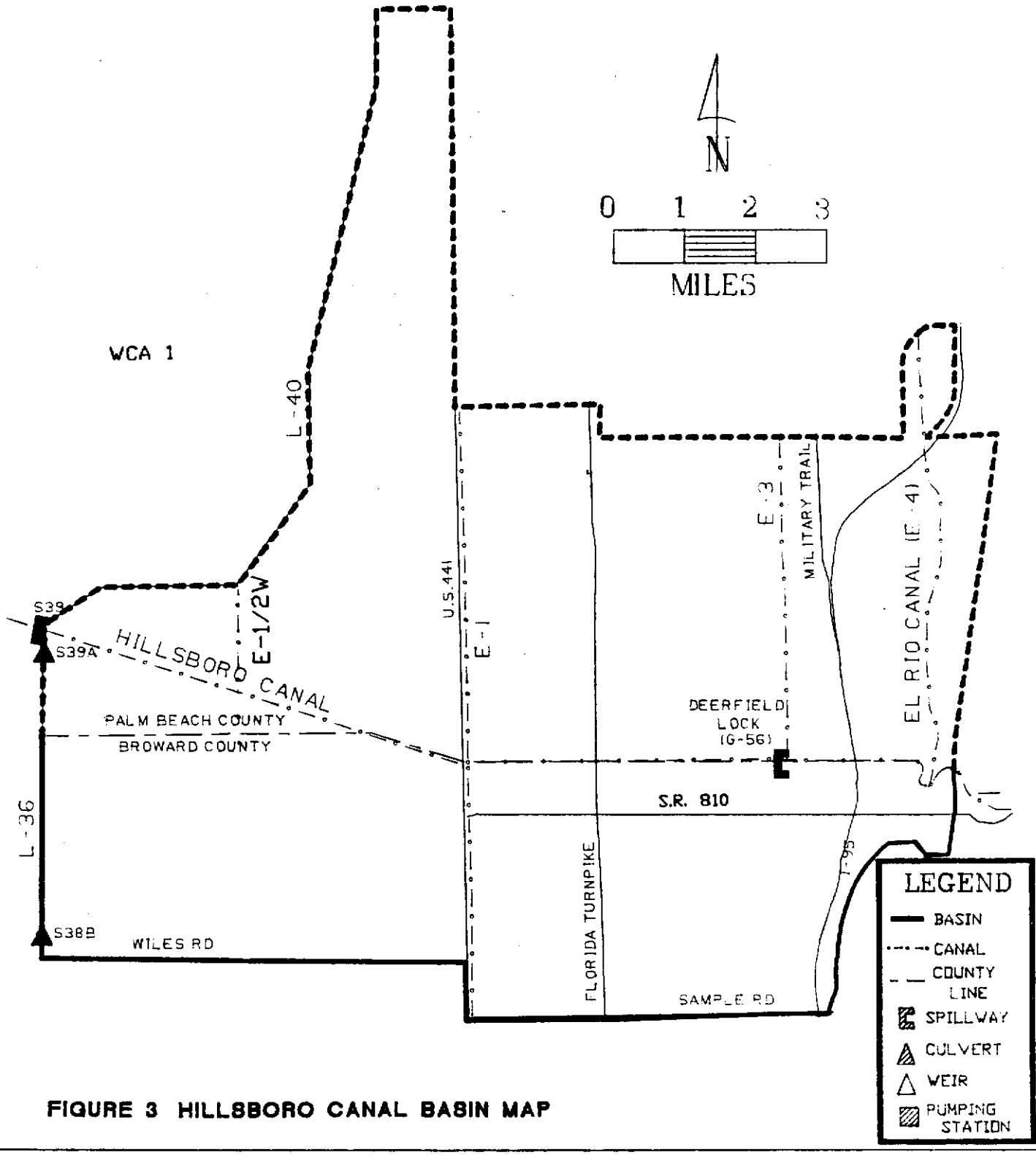



**FIGURE 3 HILLSBORO CANAL BASIN MAP**

TABLE 1. Hillsboro Canal Basin Structures - Design Criteria

| Structure | Type | Design HW Stage (ft NGVD) | Design TW Stage (ft NGVD) | Optimum Stage (ft NGVD) | Design Q (cfs) | Peak Stage (ft NGVD) and Q (cfs) | Date of Peak Occurrence |
|---|---|---|---|---|---|---|---|
| Deerfield Lock (G-56) Stage divide | Weir with flashboards 5-bays, 12ft each Crest lgth = 60ft Crest elev = 1.0ft NGVD Gated spillway Crest lgth = 25 ft Crest elev = -4.5ft NGVD | 4.0 | 3.5 | HW = 7.7 | 1600 | HW = 10.86 TW = 9.2 Q = 3700 | 4/25/79 10/15/65 4/25/79 |
| S-39 Water supply, regulatory releases to Hillsboro Canal from WCA-1 | Spillway Taintor Gate 16 ft x 9.2 ft Weir lgth = 15 ft. Crest elev = 2.5ft NGVD | 11.0 | 9.0 | TW = 9.0 max. HW = WCA 1 Regulation schedule | 800 | TW = 12.39 | 10/15/65 |
| S-39A Stage divide | Culvert with riser and stop logs 3-72 in x 54 ft. CMP | | | HW = 7.0-7.5 | | | |
| S-38B Divide C-14 and Hillsboro basins | Gated Culvert 1-66in x 72ft CMP Invert elev = 0ft NGVD | 9.0 | 7.65 | | | | |

in = inches
ft = feet
elev = elevation
lgth = Length
TW = Tail water
Q = discharge in cfs
CMP = Corrugated metal pipe
RCP = Reinforced concrete pipe
ft NGVD = Feet relative to National Geodetic Vertical Datum
HW = Head water
CFS = Cubic feet per second
ds = downstream
ups = upstream

## C-14 (CYPRESS CREEK CANAL) BASIN

### Description of the Basin

The C-14 basin has an area of 59 square miles and is located in northeastern Broward County. The C-14 basin is divided into an eastern basin (34 square miles, Figure 4) and a western basin (25 square miles, Figure 6). The boundary between the basins is two miles west of U. S. Highway 441. The basin boundaries relative to local roads and landmarks are shown on Map A. Schematic maps showing the basin boundaries, canals and control structures for the C-14 basins are given in Figures 5 and 7.

The Project canals and control structures in the C-14 basin have five functions: (1) to provide flood protection and drainage for the basin, (2) to supply water to the C-14, the Pompano Canal and the C-13 basins during periods of low natural flow, (3) to convey excess water in Water Conservation Area (WCA) 2A to tidewater, (4) to intercept and control seepage from WCA 2A, and (5) to maintain a groundwater surface elevation west of S-37A adequate to prevent saltwater intrusion into local groundwater. Excess water in the basin is discharged to tidewater by way of C-14 and S-37A. Excess water in WCA 2A is discharged to C-14 by way of S-38 and subsequently to tidewater by way of S-37A. Water surface elevations in C-14 are regulated by S-37A and S-37B. Water supply to the basin is from WCA 2A by way of S-38, by way of seepage from WCA 2A to the L-36 borrow canal, and from local rainfall. The rate of seepage to the L-36 borrow canal is regulated by the stage held in the canal by S-38A and S-38B. Water from C-14 can be supplied to the C-13 basin by way of S-38C and can be supplied to the Pompano Canal basin by way of G-65.

There are two Project canals in the C-14 basin: C-14 and the section of the L-36 borrow canal between C-14 and S-38B.

C-14 is aligned east-west in the alignment of the old Pompano Canal from the L-36 borrow canal to a point approximately one-half mile east of Florida's Turnpike. East of that point, the canal alignment follows the old channel of Cypress Creek. Direction of flow in the canal is to the east with discharge to the Intracoastal Waterway about three-quarters of a mile south of State Road 814. A short reach of canal connects C-14 to the Pompano Canal. This interconnecting canal makes an open channel connection with C-14 one-half mile east of Florida's Turnpike, and it connects to the Pompano Canal by way of G-65 at 21st Avenue, one-quarter mile west of Powerline Road. Since G-65 is normally closed, flow in this canal is usually to the west to C-14. When G-65 is opened to supply water to the Pompano Canal basin, flow in the canal is reversed.

The L-36 borrow canal is aligned north-south along the western boundary of the basin. Only that part of the canal north of C-14 is in the C-14 basin. Direction of flow in the northern part of the L-36 borrow canal is to C-14. The part of the L-36 borrow canal south of C-14 conveys water from C-14 to the C-13 basin. It does not contribute flow to the C-14 basin.

There are seven Project control structures regulating flow in the C-14 basin: S-37A, S-37B, S-38, S-38A, S-38B, S-38C, and G-65. Design criteria for these structures are given in Table 2.

S-37A is a gated spillway located in the alignment of C-14 just east of Dixie Highway. It controls water surface elevations in C-14 upstream to S-37B, and it regulates discharges to tidewater. In so far as is possible a headwater stage of 3.5 ft NGVD is maintained by S-37A. This is usually adequate to prevent saltwater intrusion into local groundwater.

S-37B is a gated spillway located in the alignment of C-14 three-quarters of a mile southeast of the Florida's Turnpike crossing of C-14. It controls water surface elevations upstream in C-14, and it regulates discharges downstream in C-14. In so far as is possible a headwater stage of 7.5 ft NGVD is maintained by S-37B. This is usually adequate to prevent saltwater intrusion into local groundwater.

S-38 is a gated culvert through L-36 at the west end of C-14. It has two functions: (1) to supply water to the C-14 and C-13 basins during periods of low natural flow, and (2) when the stage in WCA 2A is above the regulation schedule, to discharge water from the WCA to tidewater by way of C-14. Water releases are made as necessary to maintain the optimum stages in C-13 and C-14. Regulatory discharges through S-38 are made only if the water is not needed in WCA 3A, and C-14 can accept additional water without flooding occurring in the basin. No discharges are made at S-38 if the tailwater stage exceeds 8.2 ft NGVD.

S-38A is a culvert located in the alignment of the L-36 borrow canal just north of C-14. Control of water flow is affected by a riser and flashboards. Together with S-38B, S-38A controls the rate of seepage from WCA 2A to the L-36 borrow canal by regulating the water level in the borrow canal. Normally a stage of 7.65 ft NGVD is maintained in the canal. Excess runoff, pumped drainage, and seepage to the L-36 borrow canal south of S-38B are discharged to C-14 by way of S-38A.

S-38B is a gated culvert located in the alignment of the L-36 borrow canal just north of Wiles Road at the North Springs Improvement District pump station. The structure is always closed and acts as a divide between the Hillsboro Canal basin and the C-14 basin. The pump station discharges up to 110 cfs of water to either side of S-38B. This water is drainage from the southeast corner of the Hillsboro Canal basin.

S-38C is a gated culvert located in the alignment of the L-36 borrow canal just south of C-14. It is normally closed and acts as a divide between the C-13 and C-14 basins. If water is available in C-14, S-38C may be opened as necessary to supply water from C-14 to the C-13 basin.

G-65 is a gated culvert located in the alignment of the Pompano Canal at 21st Avenue one-quarter mile west of Powerline Road. It is normally closed and acts as a divide between the Pompano Canal and C-14 basins. If water is available in C-14, G-65 may be opened as necessary to maintain the optimum headwater stage at G-57. G-57 is a control structure in the Pompano Canal basin. Please refer to that basin description for information on the location and operation of G-57.

**Comments on Design and Historic Operation**

The C-14 is divided into two regions with regard to design flood protection: a western basin and an eastern basin. The western basin was designed for 1-10 year flood protection, and the eastern basin was designed for 1-30 year flood protection. Runoff from the eastern basin enters C-14 by gravity flow. In the western basin, the Cities of Coral Springs and North Lauderdale, and portions of the City of Tamarac pump their runoff to C-14. The balance of the western basin drains to C-14 by gravity flow.

A 3500 foot reach of C-14 just upstream of S-37B was designed and built with too small of a cross-sectional area. Velocities in this reach are as high as 2.85 feet per second. The canal is being eroded with subsequent deposition of materials downstream. Excavation of this reach would lower the hydraulic profile of the canal for the design storm by as much as three-tenths of a foot. The District has adequate right-of-way on C-14 to do the excavation.

The western most 3.5 miles of C-14 was overexcavated. The design storm tailwater stage for S-38 at the west end of C-14 calculated for the as-built canal cross-section is 9.21 ft NGVD. The original design called for a tailwater stage of 9.92 ft. NGVD at S-38.

Rainfall amounts in the basin for the April 25, 1979 storm ranged from that of a 1-50 year storm to greater than that of a 1-100 year storm. Reported water surface elevations over flood stage ranged from approximately 0.5 feet in the areas drained by gravity flow to approximately 1.5 feet in the areas drained by pumping. A discharge of 3100 cfs was measured at U. S. Highway 441. The design discharge at this point is 2050 cfs. An estimated peak flow of 4800 cfs passed structure S-37A where the design discharge is 3890 cfs.

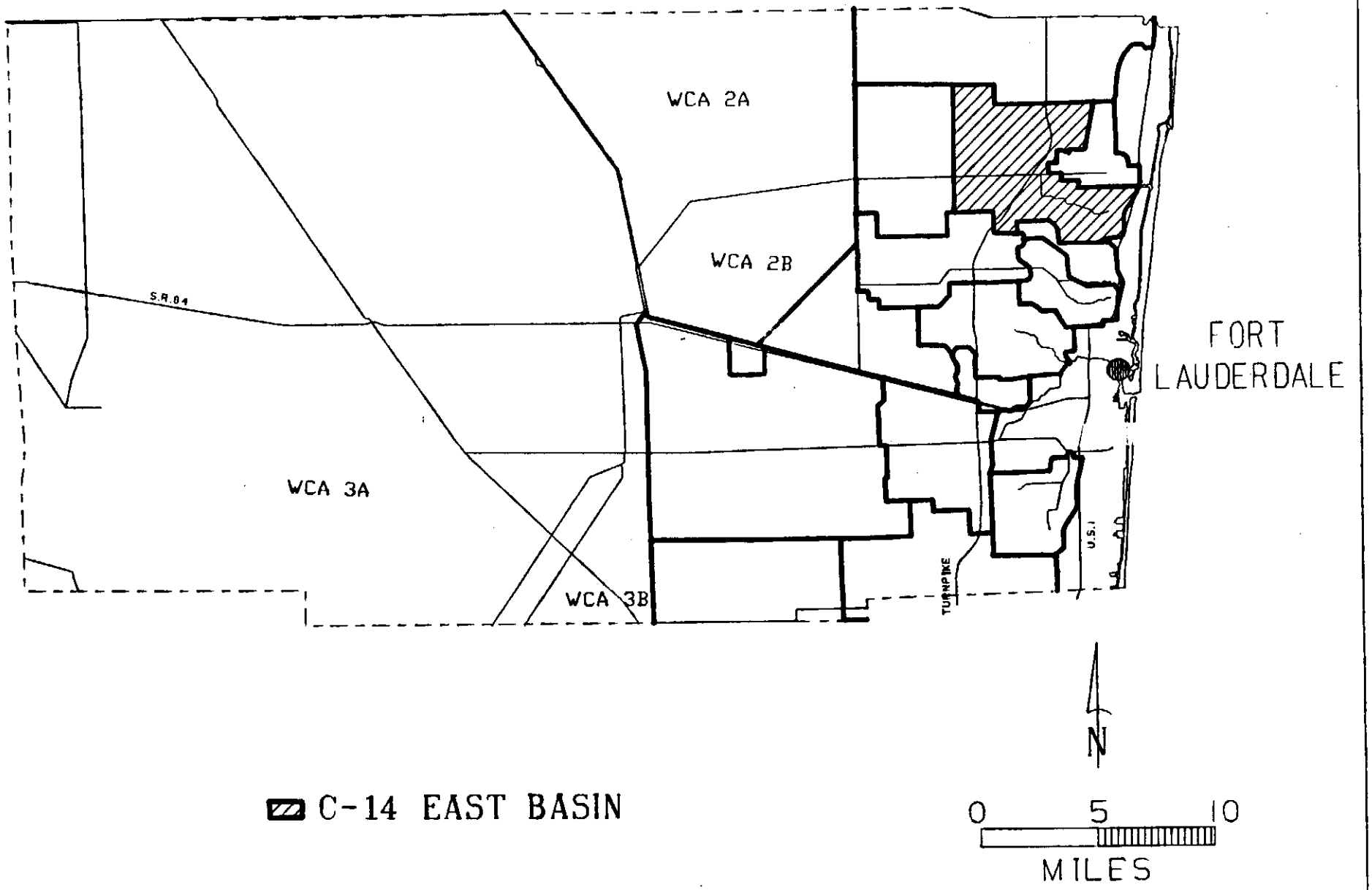



**FIGURE 4 C-14 EAST BASIN LOCATION MAP**

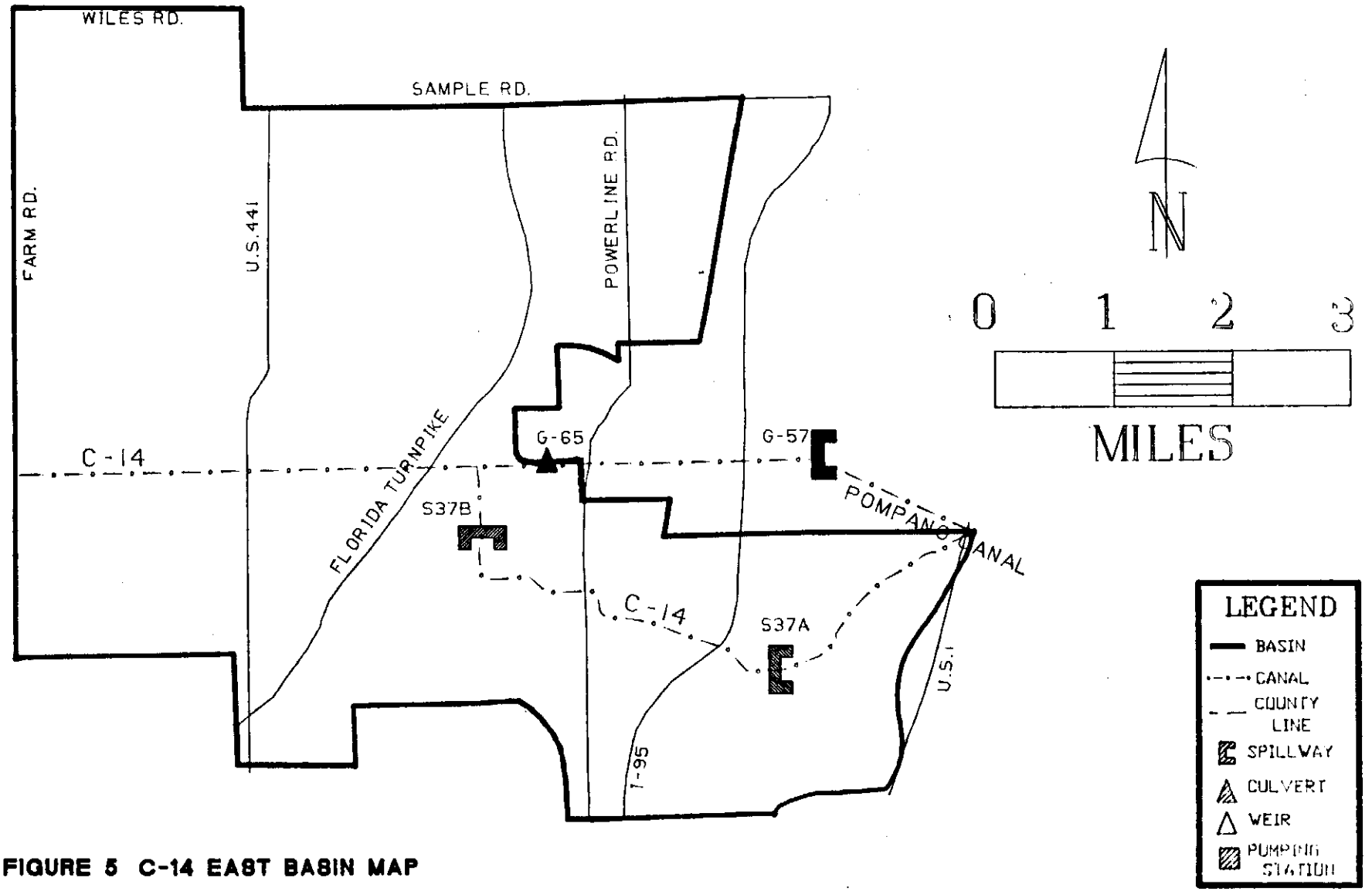



**FIGURE 5 C-14 EAST BASIN MAP**

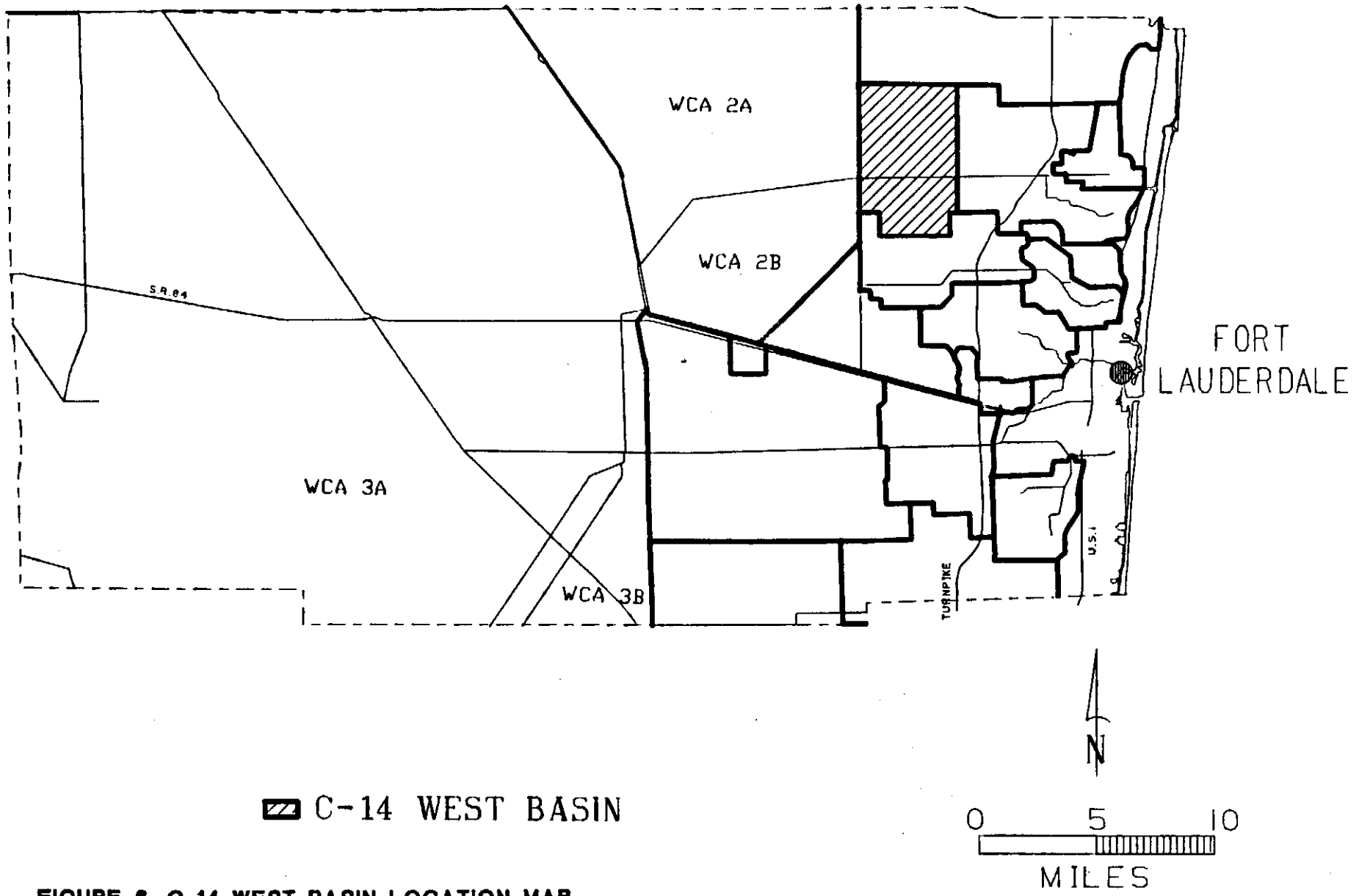



**FIGURE 6 C-14 WEST BASIN LOCATION MAP**

# C-14 WEST BASIN
# (CYPRESS CREEK)

## 15,800 ACRES

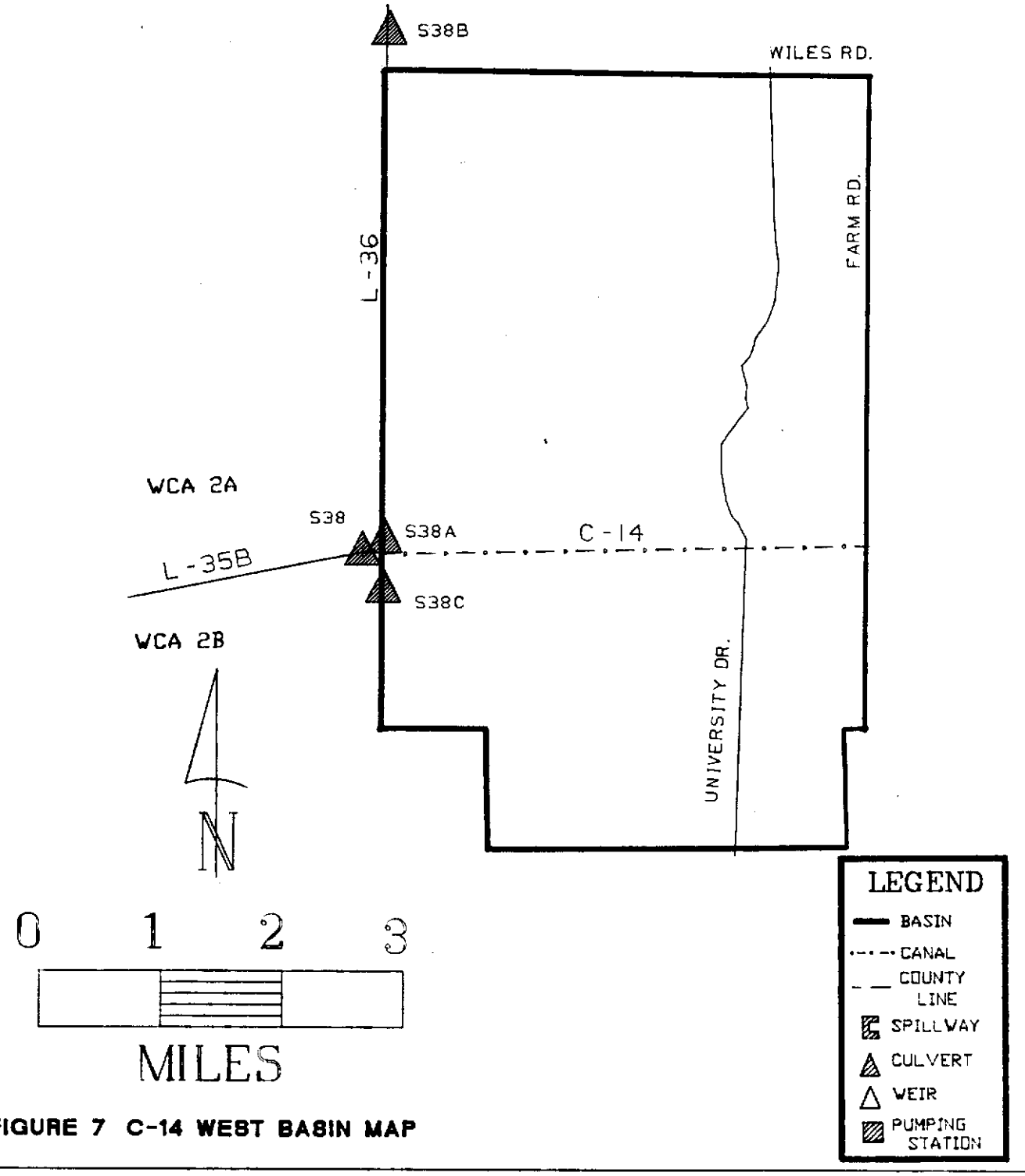



**FIGURE 7 C-14 WEST BASIN MAP**

TABLE 2. C-14 Basin Structures - Design Criteria

| Structure | Type | Design HW Stage (ft NGVD) | Design TW Stage (ft NGVD) | Optimum Stage (ft NGVD) | Design Q (cfs) | Peak Stage (ft NGVD) and Q (cfs) | Date of Peak Occurrence |
|---|---|---|---|---|---|---|---|
| S-37A Stage divide | Spillway, 2 gates 25ft x 12.8ft Crest lgth = 50ft Crest elev = -7.7ft NGVD | 3.0 | 2.0 | HW = 3.5 | 3890 | HW = 5.19<br>TW = 4.28<br>Q = 3800<br>Q = 3060 (measured) | 4/25/79<br>4/25/79<br>4/25/79<br>4/26/79 |
| S-37B Stage divide | Spillway, 2 gates 25ft x 6.6ft Crest lgth = 50ft Crest elev = 0 ft NGVD | 7.2 | 4.7 | HW = 7.5 | 3390 | HW = 8.99<br>TW = 6.14<br>Q = 3108 (measured) | 4/25/79<br>4/25/79<br>4/25/79 |
| G-65 Divide C-14 and Pompano Canal | Gated Culvert 1-54in x 1500ft RCP Invert elev = 0 ft NGVD | | | TW = 4.5 (at G-57) | 50-55 (water supply) | | |
| S-38C Stage divide, C-13 and C-14 water supply C-13 | Culvert with risers and stop logs 2-72 in x 35 ft CMP invert elev = 1.55 ft NGVD | | | | | | |
| S-38A Stage divide, L-36 stage and C-14 stage | Culvert with risers and stop logs 2-60 in x 70 ft CMP invert elev = 2.0 ft NGVD | 9.0 | 8.0 | HW = 7.65 | 190 | | |
| S-38 Water supply,C-13 and C-14 | Gated Culvert 2-72in x 52ft Invert elev = 2ft to 3ft NGVD | 9.8 | 7.0 | TW = 8.2 max. (not to exceed 8.2) | 500 | HW = 15.47<br>TW = 10.47<br>Q = 586 | 11/15/69<br>4/25/79<br>9/22/66 |
| S-38B Divide C-14 and Hillsboro basins | Gated Culvert 1-65in x 72ft CMP Invert elev = 0ft NGVD | 9.0 | 7.65 | | | | |

in = inches
ft = feet
elev = elevation
lgth = Length
TW = Tail water
Q = discharge in cfs
CMP = Corrugated metal pipe
RCP = Reinforced concrete pipe
ft NGVD = Feet relative to National Geodetic Vertical Datum
HW = Head water
CFS = Cubic feet per second
ds = downstream
ups = upstream

## POMPANO CANAL BASIN

### Description of the Basin

The Pompano Canal basin has an area of approximately 7.2 square miles and is located in northeastern Broward County (Figure 8). The basin boundary relative to local roads and landmarks is shown on Map A. A schemetic map showing the basin boundary, canals and control structures is given in Figure 9.

The Project canal and control structures in the Pompano Canal basin have three functions: (1) to provide flood protection and drainage for the Pompano Canal basin, (2) to supply water to the basin during periods of low natural flow, and (3) to maintain a groundwater table elevation west of G-57 adequate to prevent intrusion of saltwater into local groundwater. Excess water in the basin is discharged to tidewater by way of G-57. G-57 also regulates water surface elevations in the Pompano Canal. Water supply to the basin is from C-14 by way of G-65 and from local rainfall.

The Pompano Canal is the only Project Canal in the Pompano Canal basin. It is aligned east-west, south of and approximately parallel to Atlantic Avenue from 21st Avenue (one-quarter mile west of Powerline Road) to Cypress Road. East of Cypress Road, the canal is aligned northwest to southeast and extends from Cypress Road to the Intracoastal Waterway. At its west end at 21st Avenue, the canal connects to C-14 by way of G-65. At its east end the canal makes an open channel connection with the Intracoastal Waterway about three-quarters of a mile south of State Road 814. Direction of flow in the canal is to the east with discharge to the Intracoastal Waterway.

There are two Project control structures regulating flow in the Pompano Canal basin: G-57 and G-65. Design criteria for the structures are given in Table 3.

G-57 is a steel sheet-pile barrier with a six-bay weir. Control of water flow is affected by flashboards. The structure controls water surface elevations upstream in the Pompano Canal, and it regulates discharges to tidewater. In so far as is possible the headwater stage at G-57 is maintained at 4.5 ft NGVD. During flood conditions the headwater stage is reduced to 2.5 ft NGVD. These stages are adequate to prevent intrusion of saltwater into local groundwater. G-57 is also known as the City Spillway or as the Pompano Canal Salinity Structure.

G-65 is a gated culvert located in the alignment of the Pompano Canal at 21st Avenue one-quarter mile west of Powerline Road. It is normally closed and acts as a divide between the Pompano Canal and C-14 basins. If water is available in C-14, G-65 may be opened as necessary to maintain the optimum headwater stage at G-57.

### Comments on the Design and Historic Operation

The present Pompano Canal is the remnant of the longer, original Pompano Canal. It has 1-25 year flood protection. When C-14 was constructed, the portion of the Pompano Canal west of Powerline Road was made part of the C-14 Canal. A plug and a divide structure, G-65, were placed in the Pompano Canal at Powerline

Road. The Pompano Canal originally had two control structures. The Market Spillway has been removed, however, leaving only the City Spillway for control of water surface elevation in the canal. The District intends to replace the City Spillway with a more modern structure at the same location. The structure is currently being designed and will be built at District expense.

During the 1970's, G-65 was increased in length by 1500 ft and the control moved to 21st Avenue. The canal downstream to State Road 811 was partially filled so that Atlantic Avenue could be widened. Only enough channel was left to pass the design flow.

The Department of Transportation (D.O.T.) has asked permission of the District to replace portions of the canal east and west of State Road 811 with box culverts sized to pass the design flow. The D.O.T. proposal has been approved and will be under construction in the summer of 1987.

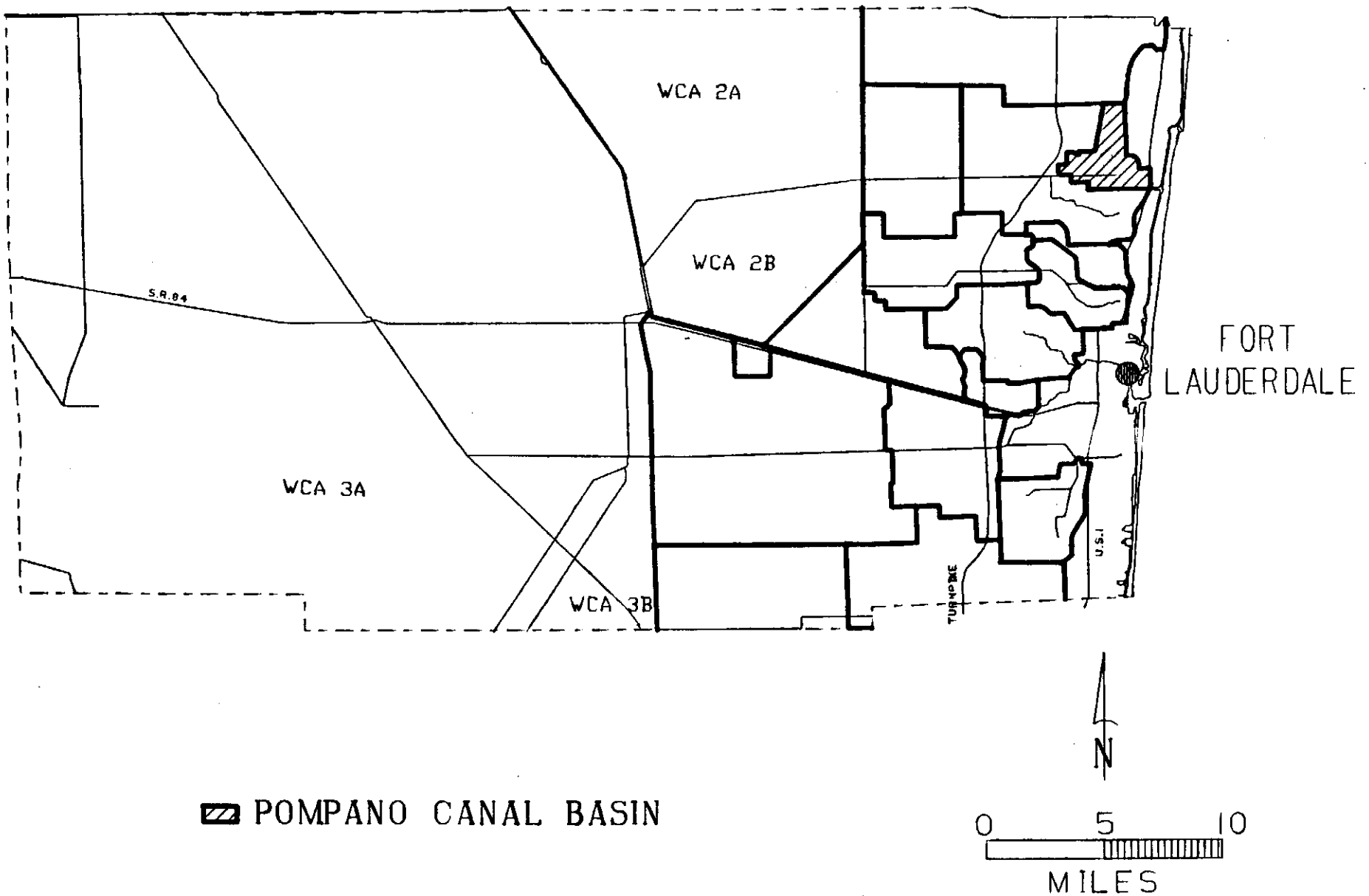
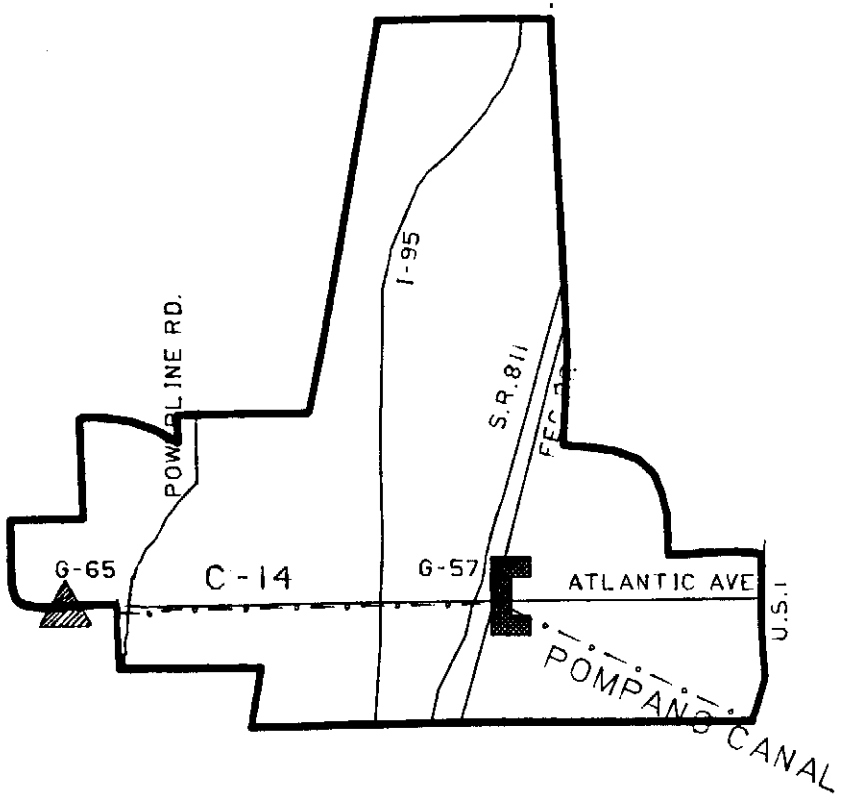



**FIGURE 8 POMPANO CANAL BASIN LOCATION MAP**

# POMPANO CANAL

## 4,600 ACRES



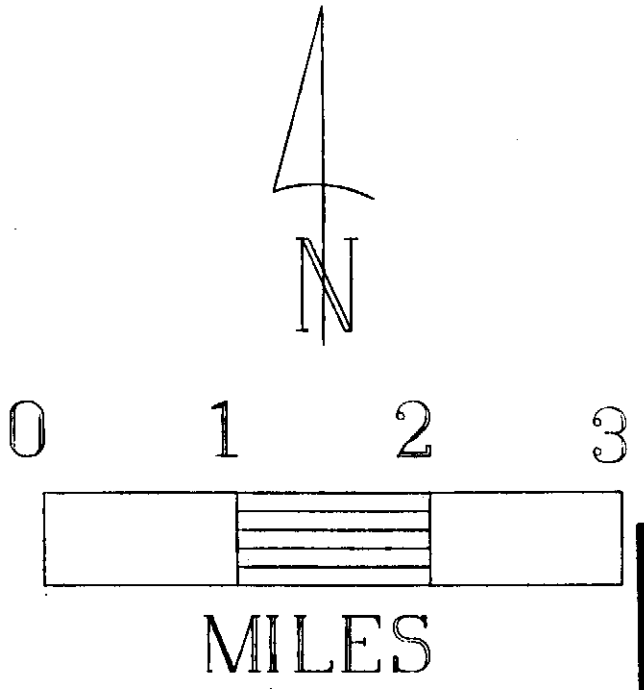




**FIGURE 9 POMPANO CANAL BASIN MAP**

TABLE 3. Pompano Canal Basin Structures - Design Criteria

| Structure | Type | Design HW Stage (ft NGVD) | Design TW Stage (ft NGVD) | Optimum Stage (ft NGVD) | Design Q (cfs) | Peak Stage (ft NGVD) and Q (cfs) | Date of Peak Occurrence |
|---|---|---|---|---|---|---|---|
| G-57 Stage Divide | Steel sheet-pile dam with 6-bay, flashboard controlled weir Net lgth = 31.5ft Crest elev = -2.5ft NGVD | | | HW = 4.5 (dry season) HW = 2.5 (flood conditions) | 375 | HW = ~5.5 | 1970 |
| G-65 Divide C-14 and Pompano Canal | Gated Culvert 1-54in x 1500ft RCP Invert elev = 0.0ft NGVD | | | TW = 4.5 (at G-57) | 50-55 (water supply) | | |

in = inches
ft = feet
elev = elevation
lgth = Length
TW = Tail water
Q = discharge in cfs
CMP = Corrugated metal pipe
RCP = Reinforced concrete pipe
ft NGVD = Feet relative to National Geodetic Vertical Datum
HW = Head water
CFS = Cubic feet per second
ds = downstream
ups = upstream

## C-13 (MIDDLE RIVER CANAL) BASIN

### Description of the Basin

The C-13 basin has an area of approximately 39 square miles and is located in eastern Broward County. The C-13 basin is divided into an eastern basin (9 square miles, Figure 10) and a western basin (30 square miles, Figure 12). The boundary between the basins runs approximately north-south through S-36. A five square mile area north of the eastern C-13 basin drains to the North Fork of the Middle River and is known as the North Fork of the Middle River basin (Figure 14). This basin includes no Project canals or control structures. The basin boundaries of the eastern and western C-13 basins and the North Fork of the Middle River basin are shown on Map A. Schematic maps showing the eastern and western C-13 basins with their canals and control structures, and the North Fork of the Middle River basin are given in Figures 11, 13, and 15 respectively.

The Project canals and control structures in the C-13 basin have five functions: (1) to provide flood protection and drainage for the basin, (2) to supply water to the C-13 basin during periods of low natural flow, (3) to intercept and control seepage from Water Conservation Area (WCA) 2B, (4) to supply water to the City of Plantation in the North New River Canal (NNRC) basin, and (5) to maintain a groundwater table elevation west of S-36 adequate to prevent intrusion of saltwater into local groundwater. Excess water in the western basin is discharged to the eastern basin and subsequently to the North and South Forks of the Middle River by way of S-36, and occasionally to the NNRC basin by way of S-125. S-36 also regulates water surface elevations in the reach of C-13 in the western basin. S-125 usually divides flow in C-42 between the C-13 and the NNRC basins. Water supply to the C-13 basin is from C-14 by way of S-38C and from local rainfall.

There are three Project canals in the C-13 basin: C-13, the section of the L-36 borrow canal between C-14 and L-35A, and the section of C-42 between S-125 and L-35A.

C-13 is aligned east-west extending from C-42 on the west to the Intracoastal Waterway on the east. C-13 makes an open channel connection with C-42, 1.8 miles south of the intersection of L-35A and L-36. At the I-95 crossing the canal bifurcates, one channel extending to the east to connect to the North Fork of the Middle River and the other channel extending to the southeast to connect to the South Fork of the Middle River. The North Fork is the main channel for flows from C-13 to be discharged to the Intracoastal Waterway. The North Fork has been channelized while the South Fork remains in its natural state. The design criteria call for 300 cfs to be discharged to the South Fork. Flow in C-13 is to the east.

The L-36 borrow canal and C-42 form a continuous canal aligned north-south along the western side of the basin. The juncture of the two canals is at the intersection of L-36 and L-35A. Flow in these canals is to the south to C-13.

There is one other Project canal, the L-35A borrow canal, associated with the C-13 basin. The land drained by the L-35A borrow canal is in the NNRC basin, however, under non-flood conditions, runoff and seepage to the L-35A borrow canal are drained to the C-13 basin by way of C-42. Under flooding conditions the

L-35A borrow canal discharges to the NNRC by way of S-124. The operation of S-124 determines whether the L-35A borrow canal drains to the C-13 basin or to the NNRC basin. The L-35A borrow canal is aligned northeast to southwest along the northwestern border of the NNRC basin. At its north end the L-35A borrow canal makes an open channel connection to C-42 at C-42's juncture with the L-36 borrow canal. At its south end the L-35A borrow canal connects to the NNRC by way of S-124.

There are four Project control structures regulating flow in the C-13 basin: S-36, S-38C, S-125, and S-124. Design criteria for these structures are given in Table 4.

S-36 is a gated spillway located in the alignment of C-13 1.5 miles east of U.S. Highway 441. It controls water surface elevations in the western reach of C-13, and it regulates discharges to tidewater. In so far as is possible a headwater stage of 4.5 ft NGVD is maintained by S-36. This is usually adequate to prevent saltwater intrusion into local groundwater. In the event that the tailwater stage exceeds the headwater stage, the structure is closed to prevent intrusion of saltwater into the canal.

S-38C is a gated culvert located in the alignment of the L-36 borrow canal just south of C-14. It is normally closed and acts as a divide between the C-13 and C-14 basins. If water is available in the C-14 basin, S-38C may be opened as necessary to supply water from the C-14 basin to the C-13 basin.

S-125 is a gated culvert in the alignment of C-42 just south of C-13. It is normally closed and acts as a divide between the C-13 and the NNRC basins. S-125 may occasionally be opened to discharge excess water from the C-13 basin if the NNRC is not flowing to capacity and S-36 in C-13 cannot maintain the design peak stage in the western reach of C-13. S-125 may also be opened to supply water to the City of Plantation by way of C-42 if water is available in the C-13 basin.

S-124 is a gated culvert in the alignment of the L-35A borrow canal just north of the NNRC. It is not in the C-13 basin, but its operation affects flow of water in the C-13 basin. This structure is normally closed so that a high stage can be maintained in the L-35A borrow canal to reduce seepage from WCA 2B. Under these conditions, seepage and runoff to the borrow canal are discharged to the C-13 basin, and stages in the borrow canal are regulated by S-36. During flooding however, S-124 is opened, and the L-35A borrow canal discharges to the NNRC. For design flood conditions the divide in flow between the C-13 and the NNRC basins occurs at the juncture of the L-35A borrow canal with C-42 and the L-36 borrow canal.

**Comments on Design and Historic Operation**

C-13 was designed to provide 1-25 year flood protection. The original Army Corps of Engineers design called for a discharge of 1090 cfs at S-36; however, by 1972, the basin had been enlarged by some 43 percent. Additions to the basin were lands formerly in the C-14 and NNRC basins. A study conducted by the District in 1972 reported that the discharge at S-36 for a 1-25 year storm for the enlarged basin would be 1560 cfs. The study also reported that most of C-13 west of S-36 had been enlarged under various free digging contracts. The new canal sections are large enough to pass 100 percent of the Standard Project Flood (SPF) in most cases, and 200 percent of the SPF for the reach of C-13 just west of Florida's Turnpike. The

study recommendation was to enlarge the rest of C-13 to pass the runoff from a 1-25 year storm (60 percent of the SPF) for the enlarged basin.

In 1973 the District made a hydraulic analysis of the C-13 and the NNRC basins based on the changes in the drainage areas of the basins and on the cross-sections for C-13 proposed by the 1972 study. Since these basins have an open channel connection (i.e., uncontrolled) at the confluence of C-42 and the L-35A borrow canal, it was necessary to verify that the design discharges for Sewell Lock (Table 6) in the NNRC and for S-36 in C-13 (Table 4) would result in the same stage at the open channel connection between the basins. (See **Comments on Design and Historic Operation** for the NNRC Basin). The proposed cross-sections for the enlargement of C-13 were determined to be adequate as a result of the study.

The enlargement of C-13 has been completed, and as-built cross-sections of the enlarged canal have been obtained. If information about more recent constructions (e.g., bridges) that may restrict flow in the canal is obtained, new hydraulic profiles should be calculated using the as-built cross-sections.

An above design storm ( 1-50 year) occurred over the basin on April 25, 1979 . Peak discharge for a storm of this intensity was calculated to be 2390 cfs. 2270 cfs was measured at the U. S. Highway 441 crossing of C-13, approximately 1.5 miles upstream of S-36. Peak stage at S-36 was 6.98 feet NGVD, 1.4 feet above the design stage of 5.6 feet NGVD. Peak stage at University Drive was 8.04 feet NGVD, 1.1 feet above the design stage of 6.97 feet NGVD. Peak stage north of the junction of C-42 and the L-35A borrow canal was 8.66 feet NGVD, 1.5 feet above the design stage of 7.2 feet NGVD. On April 26, S-36 was still passing 1590 cfs, an amount slightly greater than the design discharge.

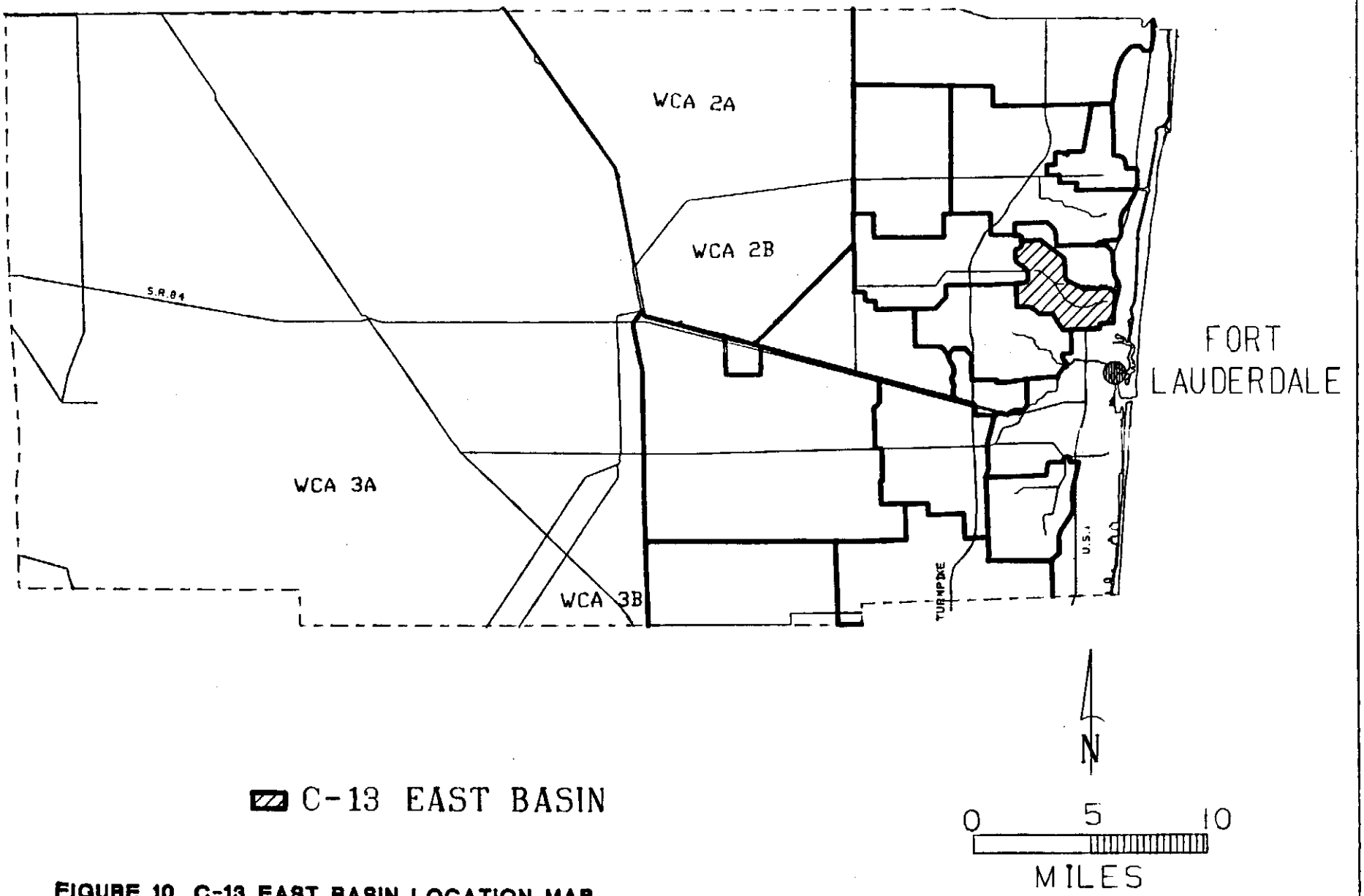
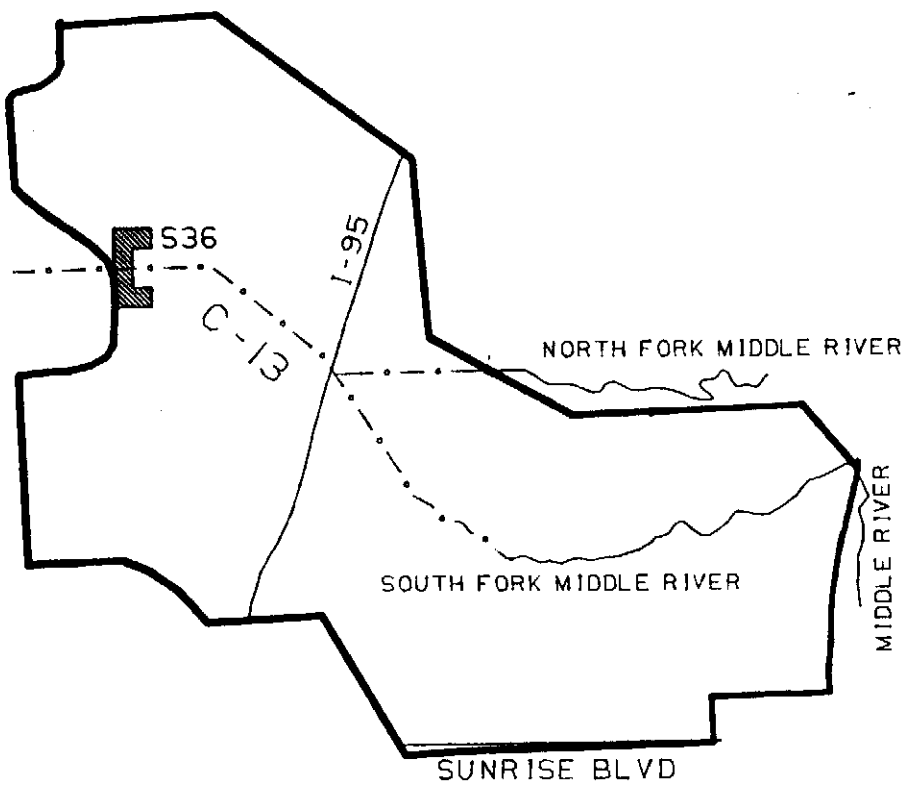
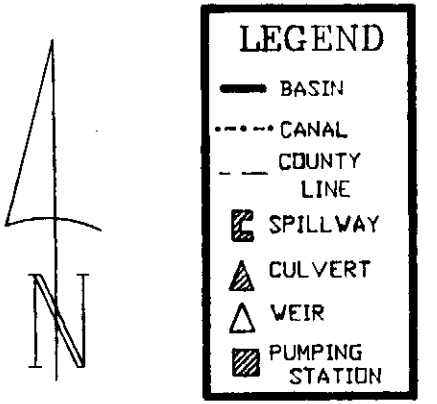



**FIGURE 10 C-13 EAST BASIN LOCATION MAP**

# C-13 EAST BASIN
# (MIDDLE RIVER CANAL)
## 5,900 ACRES







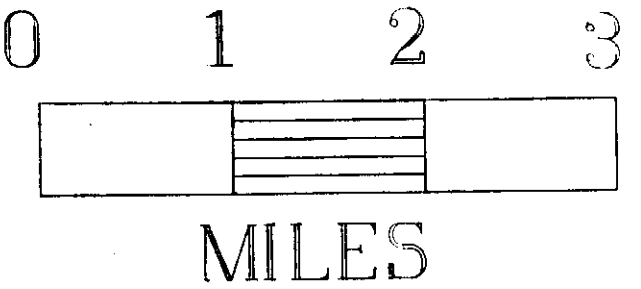



**FIGURE 11 C-13 EAST BASIN MAP**

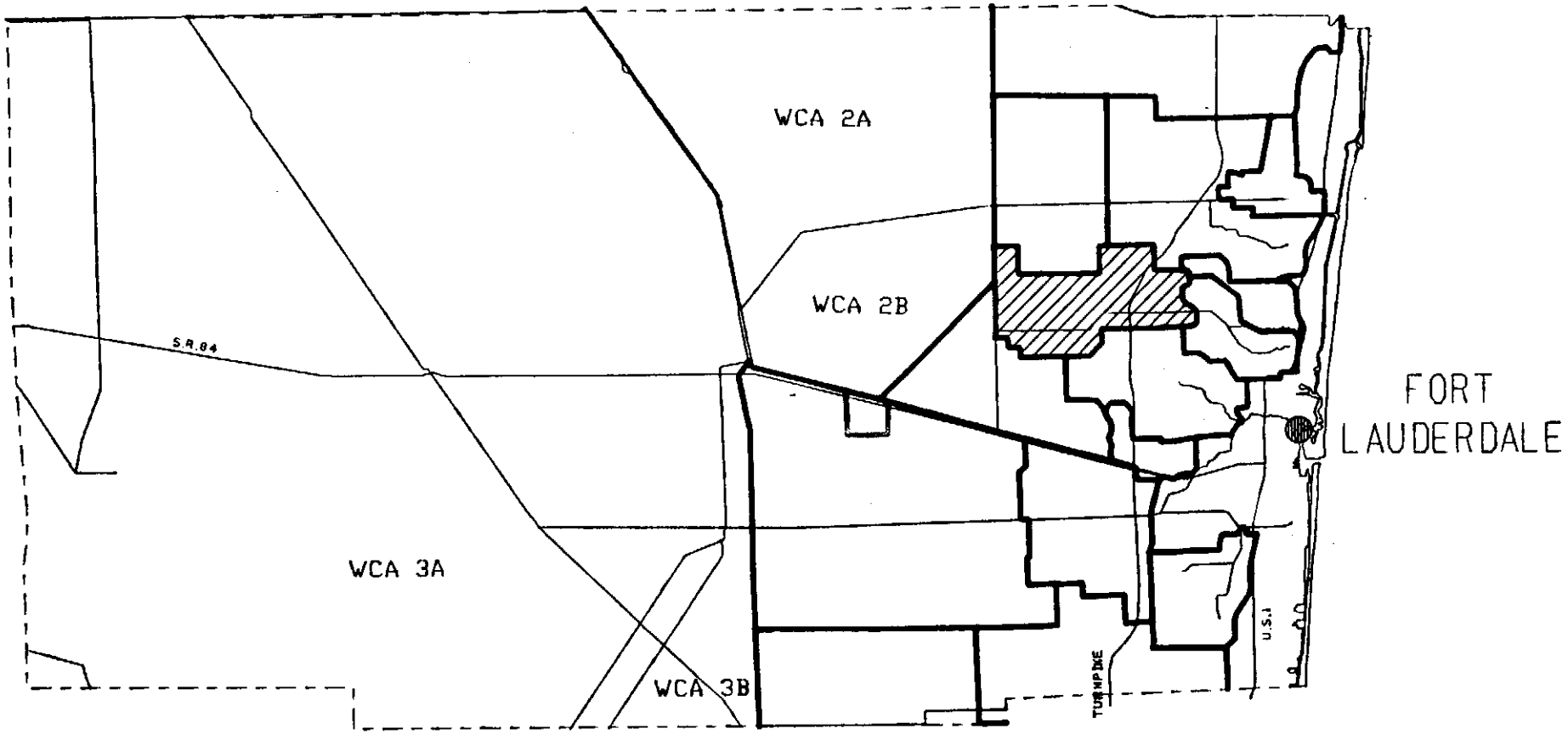



**FIGURE 12 C-13 WEST BASIN LOCATION MAP**

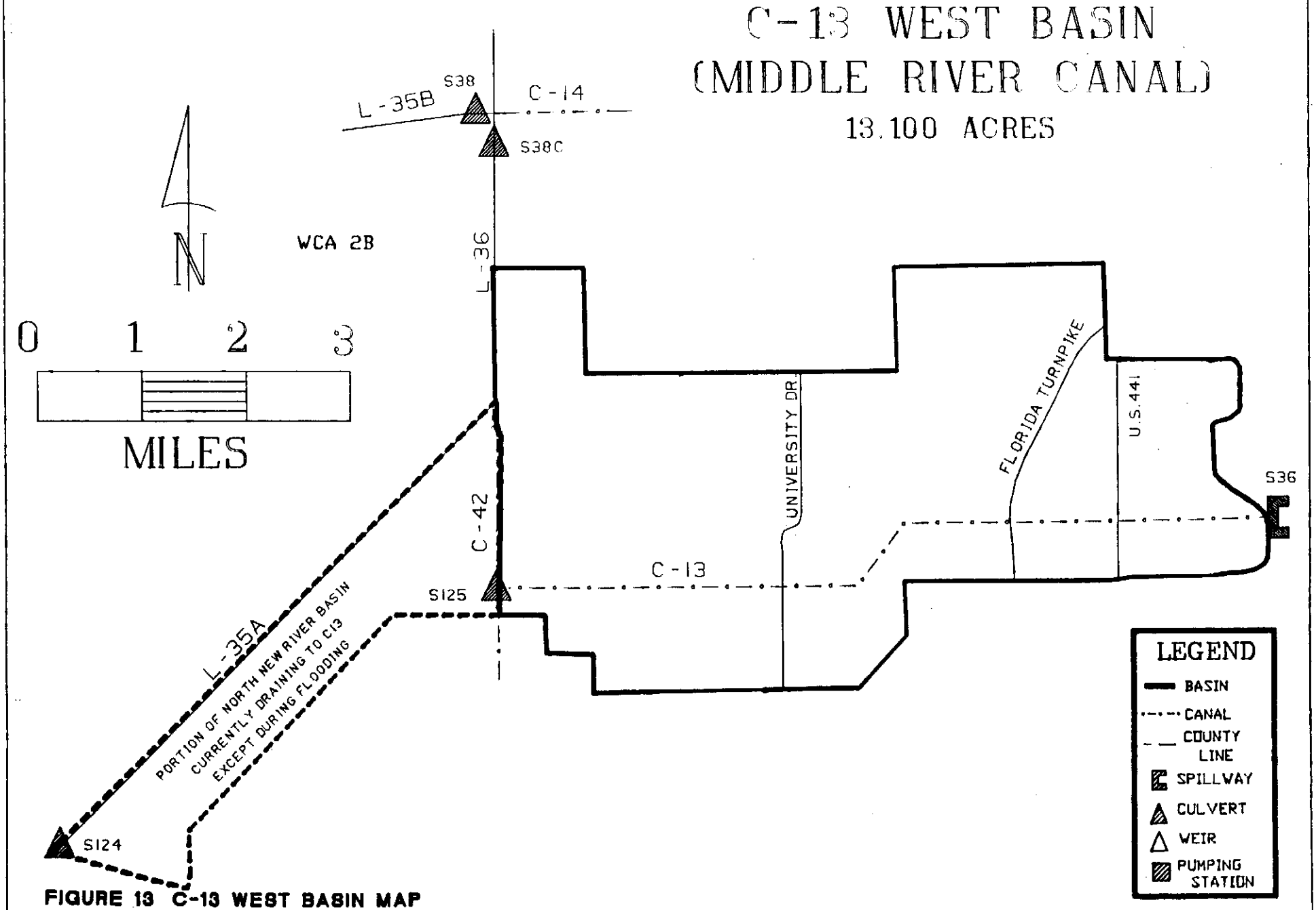



**FIGURE 13 C-13 WEST BASIN MAP**

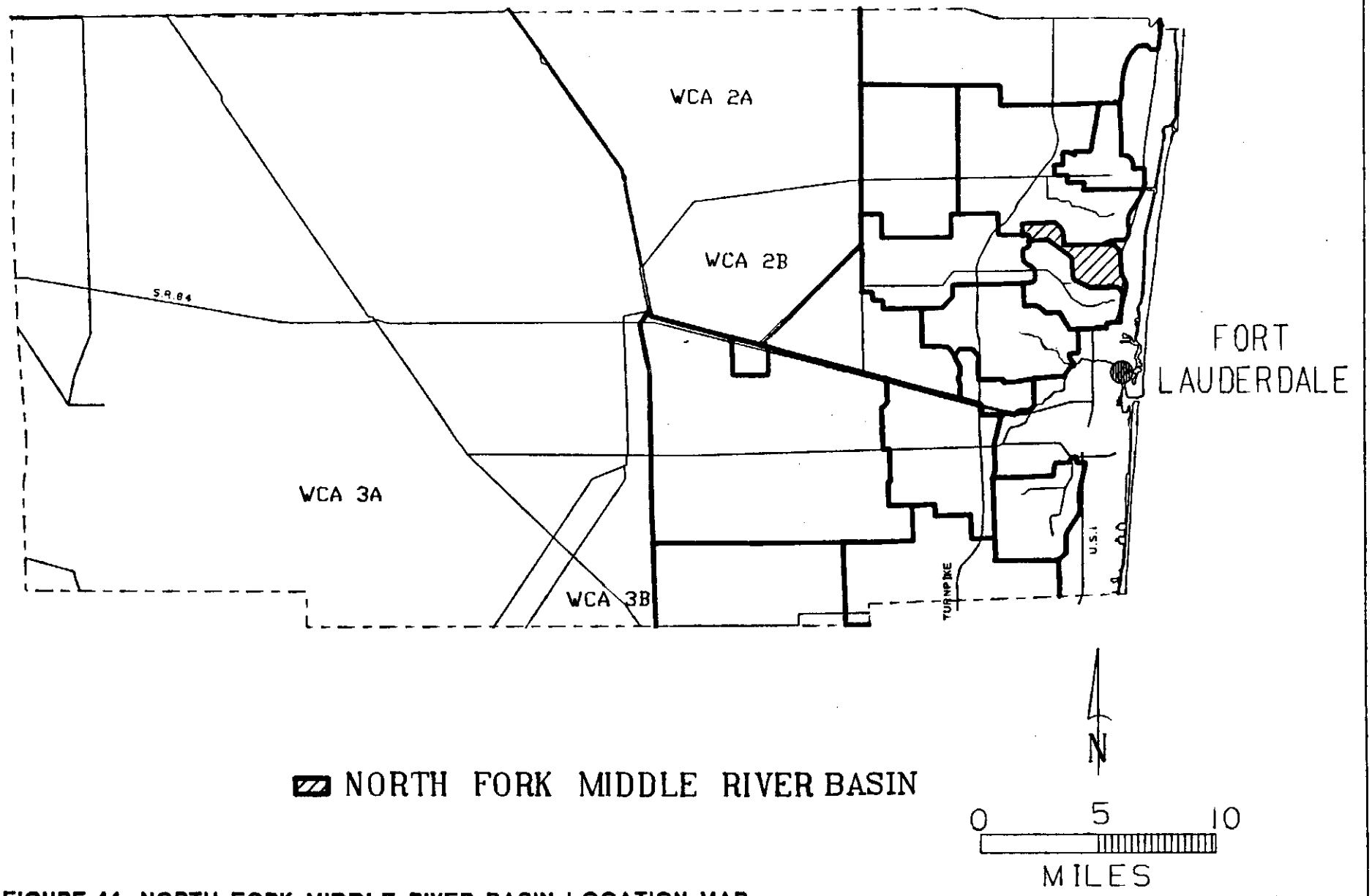



**FIGURE 14 NORTH FORK MIDDLE RIVER BASIN LOCATION MAP**

# NORTH FORK MIDDLE RIVER

## 3,400 ACRES

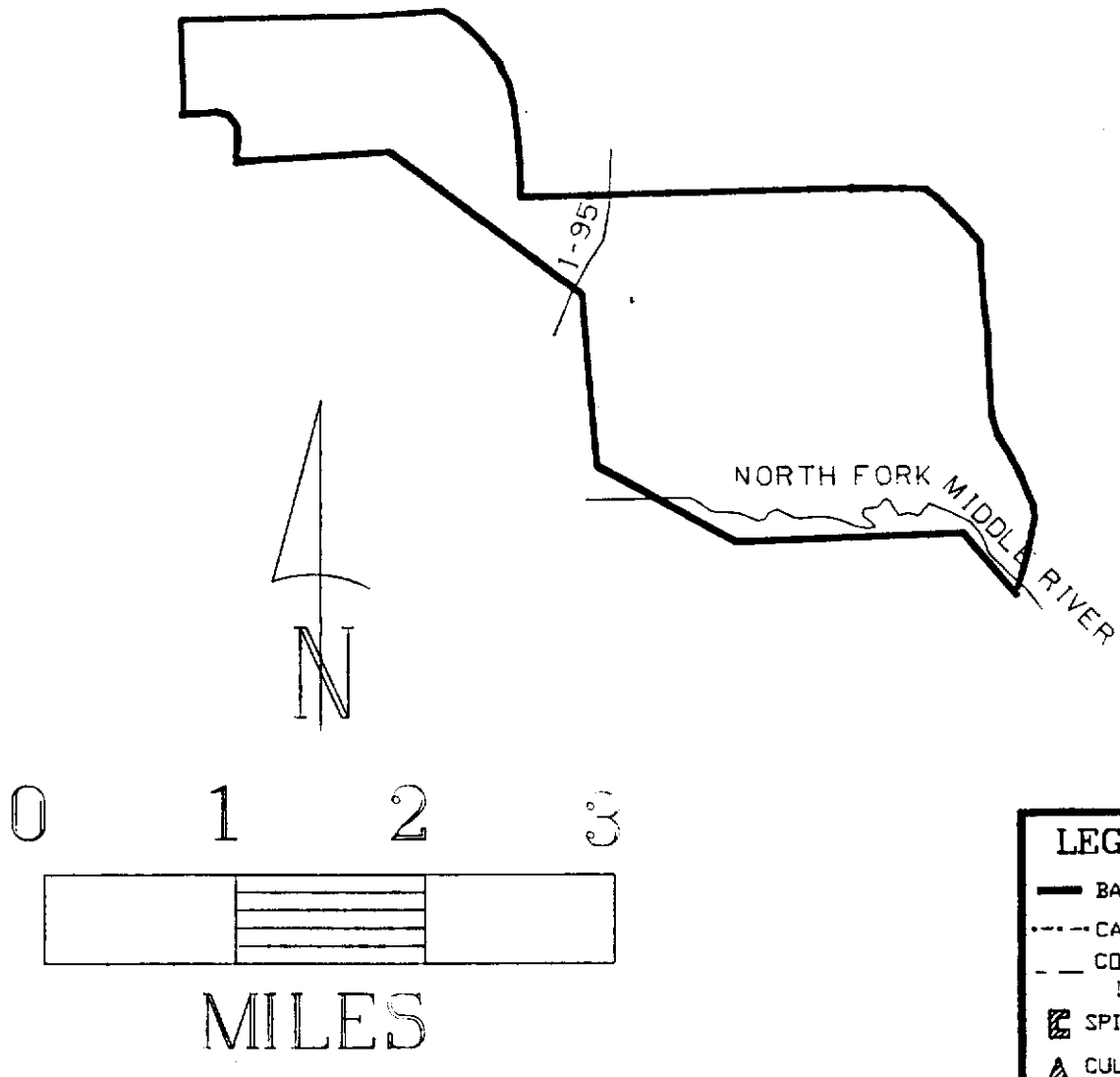



**FIGURE 15 NORTH FORK MIDDLE RIVER BASIN MAP**

TABLE 4. C-13 Basin Structures - Design Criteria

| Structure | Type | Design HW Stage (ft NGVD) | Design TW Stage (ft NGVD) | Optimum Stage (ft NGVD) | Design Q (cfs) | Peak Stage (ft NGVD) and Q (cfs) | Date of Peak Occurrence |
|---|---|---|---|---|---|---|---|
| S-36<br>C-13 | Spillway, 1-gate<br>25ft x 14ft<br>Crest lgth = 25ft<br>Crest elev = -7.0ft NGVD | 5.6 | 5.0 | HW = 4.5 | 1560 | HW = 7.38<br>TW = 5.71<br>Q = 2390 | 12/27/58<br>4/25/79<br>4/25/79 |
| S-125<br>Divide C-13 and NorthNew River Canal<br>(Water supply to City of Plantation) | Gated Culvert<br>1-48in x 40ftCMP<br>Invert elev = 2.0ft NGVD | 6.5 | 6.0 | HW = 6.0<br>TW = 3.5-4.5<br>(at Sewell Lock) | 40<br>(Regulatory releases) | HW = 8 + | 4/25/79 |
| S-38C<br>Stage divide, C-13 and C-14 water supply C-13 | Culvert<br>with risers and stop logs<br>2-72 in x 35 ft-CMP<br>invert ele = 1.55 ft NGVD | | | | | | |
| S-38<br>Water supply,C-13 and C-14 | Gated Culvert<br>2-72in x 52ft CMP<br>Invert elev = 2ft to 3ft NGVD | 9.8 | 7.0 | TW = 8.2<br>maximum | 500 | HW = 15.47<br>TW = 10.47<br>Q = 586 | 11/15/69<br>4/25/79<br>9/22/66 |
| S-124<br>Normal flow-closed<br>Flood conditions-open | Gated Culvert<br>5-72in x 48ft CMP<br>Invert elev = -1.0ft NGVD | 7.02 | 6.57 | HW = 5.0 - 5.5 | 490 | *HW = 7.8 +<br>TW = 6.86<br>*HW may have been above 8.0 | 4/25/79<br>4/25/79 |

in = inches
ft = feet
elev = elevation
lgth = Length
TW = Tail water
Q = discharge in cfs
CMP = Corrugated metal pipe
RCP = Reinforced concrete pipe
ft NGVD = Feet relative to National Geodetic Vertical Datum
HW = Head water
CFS = Cubic feet per second
ds = downstream
ups = upstream

## C-12 (PLANTATION CANAL) BASIN

### Description of the Basin

The C-12 basin has an area of approximately 19 square miles and is located in eastern Broward County (Figure 16). The basin boundary relative to local roads and landmarks is shown on Map A. A schematic map showing the basin boundary, canal and control structure is given in Figure 17.

The Project canal and control structure in the C-12 basin have two functions: (1) to provide flood protection and drainage for the basin, and (2) to maintain a groundwater table elevation west of S-33 adequate to prevent intrusion of saltwater into local groundwater. Excess water in the C-12 basin is discharged to tidewater by way of C-12 and S-33. S-33 also regulates water surface elevations in C-12. Water supply to the basin is from local rainfall.

C-12 is the only Project canal in the C-12 basin. It is aligned east-west parallel to and one-mile north of Broward Avenue from University Drive on the west to S-33 on the east. East of S-33, C-12 follows the old channel of the North Fork of the New River. Flow in the canal is to the east with discharge to the New River.
S-33 is the only Project control structure regulating flow in the C-12 basin. Design criteria for S-33 are given in Table 5.

S-33 is a gated spillway located in the alignment of C-12 four-tenths of a mile east of U.S. Highway 441. It controls water surface elevations in C-12, and it regulates discharges to tidewater. In so far as is possible, a headwater stage of 3.5 ft NGVD is maintained by S-33. This is usually adequate to prevent intrusion of saltwater into local groundwater. In the event that the tailwater stage exceeds the headwater stage, the structure is closed to prevent intrusion of saltwater into the canal.

### Comments on Design and Historic Operation

C-12 was designed to provide 1-25 year flood protection. The design called for S-33 to pass 620 cfs with a headwater stage of 5.11 ft NGVD and a tailwater stage 4.61 ft NGVD. The original U. S. Army Corps of Engineers design further specified there be no pumped inflow to the west end of the canal and that the design stage for the west end be 7.47 ft NGVD.

In 1971 the Old Plantation Water Control District requested permission to replace an existing pump station located on C-12 west of the Florida Turnpike with a new pump station with a pumping capacity of 300 cfs. The new pump station would be located at the west end of C-12. The Old Plantation Water Control District also requested that 2.3 square miles in the North New River Canal Basin be added to the C-12 basin, to be drained by the new pump station during flood conditions. During normal drainage conditions this area would continue to drain to the North New River Canal.

Gee & Jensen, a consulting engineering firm representing the Old Plantation Water Control District, and the District conducted a feasibility study of the proposal. The site investigation revealed that C-12 had been enlarged from the U. S. Highway 441 crossing of C-12 to the west end (under various free digging contracts) and that

a reach of C-12 downstream of S-33 had been realigned by Broward County. The realignment was dug with an oversize section. The recommendation of the feasibility study report was that enlarging an additional 2800 feet of C-12 to a cross-sectional area of 600 square feet would be sufficient to accommodate the extra 300 cfs of flow. The new hydraulic profile for the western reach of C-12 (west of S-33) calculated with the additional 300 cfs of flow, and the enlarged cross-section, gave a design storm stage of 7.1 ft NGVD for the west end of C-12 (a reduction of four-tenths of a foot), and a design storm stage of 5.9 ft NGVD for the headwater at S-33 (an increase of eight-tenths of a foot). The new design storm stage at the U. S. Highway 441 crossing of C-12 was 6.1 ft NGVD, one-tenth of a foot over the original U. S. Army Corps of Engineers design stage of 6.0 ft NGVD. The report concluded that this would not contribute to flooding in the area. Old Plantation Water Control District contracted for the additional excavation and was issued a permit to construct the new pumping station.

The April 25, 1979 storm was greater than a 1-25 year event. The headwater stage at S-33 was 6.13 ft NGVD, and the tailwater stage was 5.89 ft NGVD. The mean discharge for the day was 614 cfs. The new pumping station was operating to capacity.

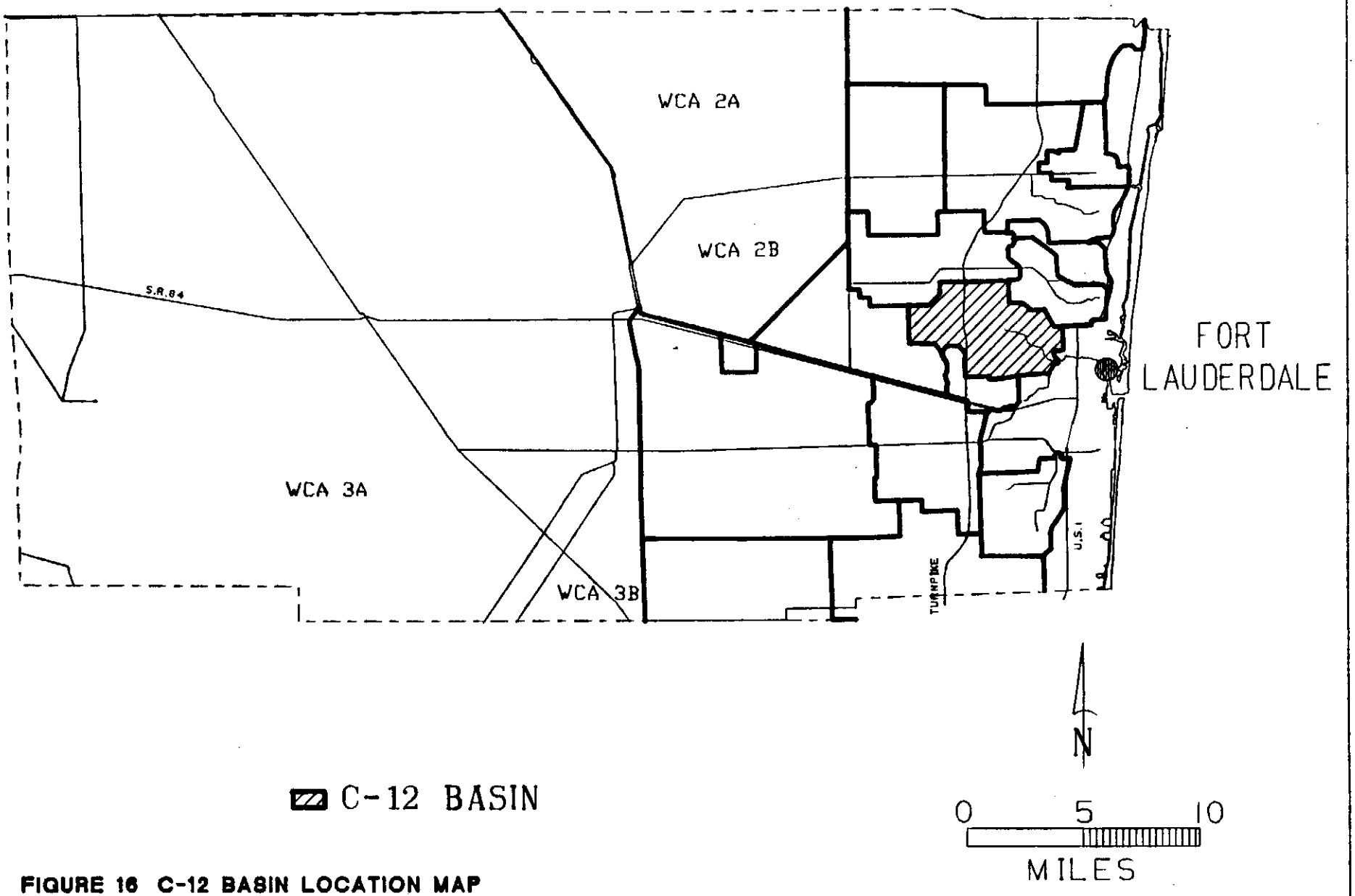



**FIGURE 16 C-12 BASIN LOCATION MAP**

# C-12 BASIN
# (PLANTATION CANAL)
## 12,100 ACRES

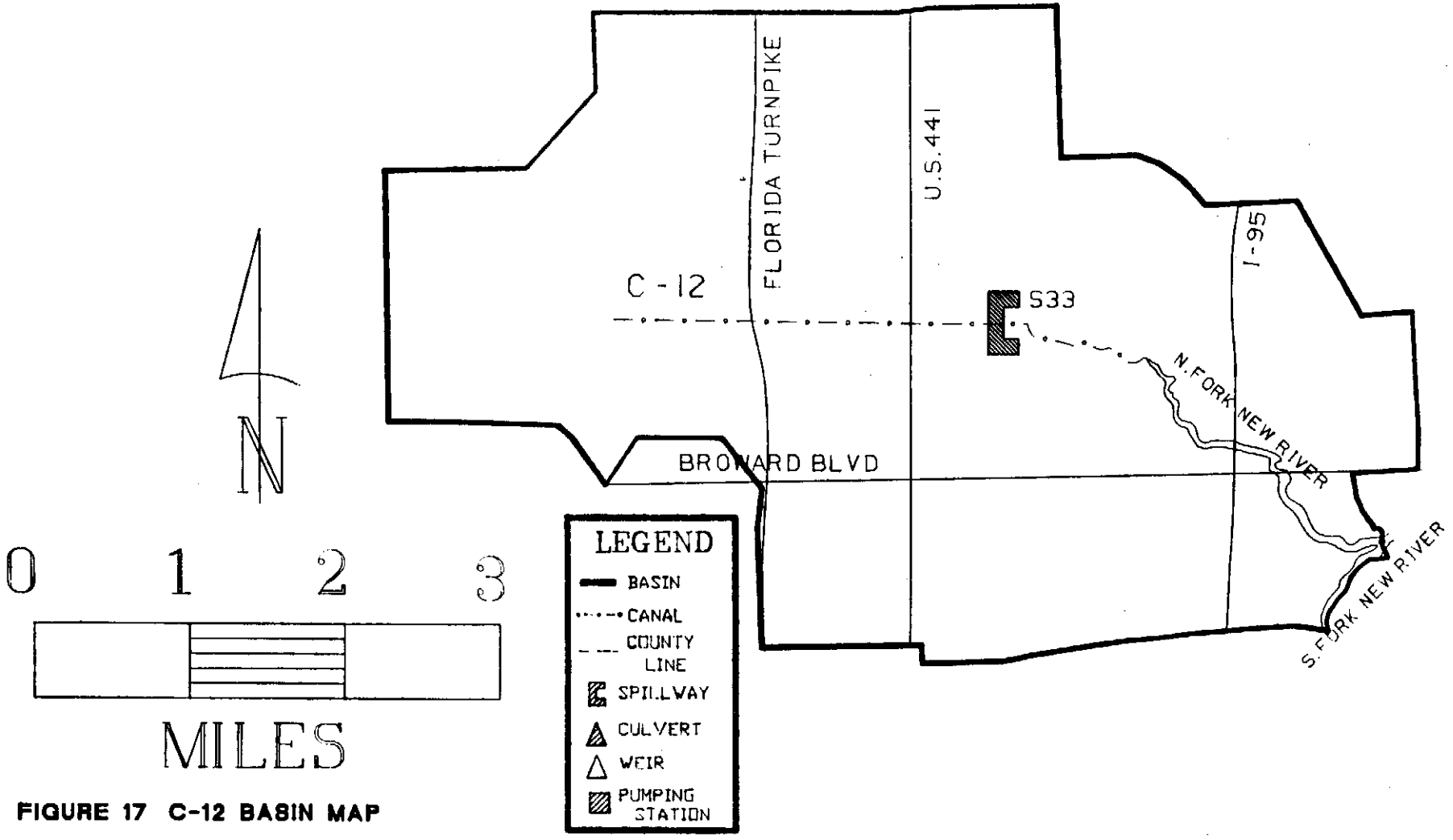



**FIGURE 17 C-12 BASIN MAP**

TABLE 5. C-12 Basin Structures - Design Criteria

| Structure | Type | Design HW Stage (ft NGVD) | Design TW Stage (ft NGVD) | Optimum Stage (ft NGVD) | Design Q (cfs) | Peak Stage (ft NGVD) and Q (cfs) | Date of Peak Occurrence |
|---|---|---|---|---|---|---|---|
| S-33<br>Stage divide | Spillway, 1-gate<br>20ft x 9 ft<br>Crest lgth = 20ft<br>Crest elev = -2.0ft NGVD | 5.9 | 4.9 | HW = 3.5 | 920 | HW = 6.13<br>TW = 5.89<br>Q = 614 | 4/25/79<br>4/25/79<br>4/25/79 |

in = inches
ft = feet
elev = elevation
lgth = Length
TW = Tail water
Q = discharge in cfs
CMP = Corrugated metal pipe
RCP = Reinforced concrete pipe
ft NGVD = Feet relative to National Geodetic Vertical Datum
HW = Head water
CFS = Cubic feet per second
ds = downstream
ups = upstream

## NORTH NEW RIVER CANAL BASIN

### Description of the Basin

The North New River Canal (NNRC) basin has an area of approximately 30 square miles and is located in eastern Broward County. The NNRC basin is divided into an eastern basin (7 square miles, Figure 18) and a western basin (23 square miles, Figure 20). The boundary between the basins is appoximately State Road 817. The basin boundaries relative to local landmarks and roads are shown on Map A. Schematic maps showing the basin boundaries, canals and control structures are given in Figures 19 and 21.

The Project canals and control structures in the NNRC have four functions: (1) to provide flood protection and drainage for the NNRC basin, (2) to supply water to the basin during periods of low natural flow, (3) to convey excess water from Water Conservation Areas (WCAs) 2A, 2B, and 3A to tidewater, and (4) to intercept and control seepage from WCA 2B. Excess water in the basin is discharged to tidewater by way of the NNRC and Sewell Lock and is pumped to WCA 3A from the NNRC by way of G-123 and S-142. Excess water in WCA 2A, 2B, or 3A is discharged to the NNRC by way of S-143, S-141, and S-142 respectively, to the NNRC basin by way of S-34, and subsequently to tidewater by way of Sewell Lock. Sewell Lock also regulates the water surface elevation in the NNRC and C-42. Water supply to the basin is from WCA 2A by way of S-143 and S-34, and from local rainfall. S-125 is occasionally used to discharge water from the C-13 basin to the NNRC basin for municipal water supply to the City of Plantation. S-125 usually divides flow in C-42 between the C-13 and the NNRC basins.

There are three Project Canals in the NNRC basin: the NNRC, the L-35A borrow canal, and C-42.

The NNRC connects Lake Okeechobee to the Atlantic Ocean. It enters the NNRC basin at S-34 near the intersection of State Road 84 and U.S. Highway 27. Within the NNRC basin, the canal is aligned parallel to and just to the north of State Road 84. Flow in the canal is to the southeast with discharge to the South Fork of the New River about four miles east of Sewell Lock.

The L-35A borrow canal is aligned northeast to southwest along the northwestern border of the basin. The land drained by the L-35A borrow canal is in the NNRC basin, however, under non-flood conditions, runoff and seepage to the L-35A borrow canal are drained to the C-13 basin by way of C-42. Under flooding conditions the L-35A borrow canal discharges to the NNRC. The operation of S-124 determines whether the L-35A borrow canal drains to the C-13 basin or discharges to the NNRC basin.

C-42 is aligned north to south parallel to and just east of Hiatus Road and is the continuation of the L-36 borrow canal south of L-35A. The canal enters the NNRC basin at S-125 just south of C-13. C-42 makes an uncontrolled open-channel connection with the NNRC one mile east of the intersection of State Road 84 and State Road 823. Flow in the canal is to the south to the NNRC.

There are eight Project control structures regulating flow in the NNRC basin: S-34, S-124, S-125, S-141, S-142, S-143, Sewell Lock (G-54), and G-123. Design criteria for the structures in this basin are given in Table 6.

S-34 is a gated culvert located in the alignment of the NNRC northeast of the intersection of State Road 84 and U.S. Highway 27. It is opened to supply water to the NNRC basin as necessary to maintain the optimum stage at Sewell Lock. Regulatory releases from WCAs 2A, 2B, and 3A are made to the NNRC upstream of S-34 and are discharged to the NNRC basin by way of S-34 provided the excess water is not needed in WCA 3A and the tailwater stage at S-34 does not exceed 6.0 ft NGVD.

S-124 is a gated culvert in the alignment of the L-35A borrow canal just north of the NNRC. This structure is normally closed so that a high stage can be maintained in the L-35A borrow canal to reduce seepage from WCA 2B. Under these conditions, seepage and runoff to the borrow canal are discharged to the C-13 basin, and stages in the borrow canal are regulated by S-36. S-36 is a control structure in C-13. Please refer to the C-13 basin description for the location and operation of S-36. During flooding however, S-124 is opened, and the L-35A borrow canal discharges to the NNRC. For design flood conditions (S-124 open) the divide in flow between the C-13 and the NNRC basins occurs at the juncture of the L-35A borrow canal with C-42 and the L-36 borrow canal.

S-125 is a gated culvert in the alignment of C-42 just south of C-13. It is normally closed and acts as a divide between the C-13 and the NNRC basins. S-125 may occasionally be opened to discharge excess water from the C-13 basin if the NNRC is not flowing to capacity and S-36 in C-13 cannot maintain the design peak stage in the western reach of C-13. If water is available in the C-13 basin, S-125 may be opened to supply water to the City of Plantation by way of C-42.

S-141 is a sheet-pile overflow section and reinforced concrete weir in L-38E at the southwest corner of WCA 2B. Control of water flow is affected by stop logs. S-141 is the only means of discharging water from WCA 2B. It is used to make releases of water from WCA 2B to the NNRC to regulate the stage in the WCA and for water supply to the NNRC basin when water is available in the WCA. Water supply releases to the NNRC are also made by way of S-143 from WCA 2A. Releases from these two structures are used to maintain an optimum stage in the NNRC at Sewell Lock of between 3.5 and 4.5 ft NGVD. Regulatory releases from WCA 2B can be made at S-141 when the stage in the WCA is above 10.0 ft NGVD and the tailwater stage at S-34 is below 6.0 ft NGVD.

S-142 is a gated culvert through L-35B, connecting WCA 3A to the North New River Canal (NNRC). It is used in conjunction with G-123 to discharge excess water from the NNRC to WCA 3A. When G-123 is pumping excess water to the NNRC upstream of S-34, S-142 is opened to pass the discharge on to WCA 3A. When the stage in WCA 3A is above its regulation schedule, S-142 may occasionally be used to discharge water from the WCA 3A to tidewater by way of the NNRC. Regulatory discharges through S-142 are made only if the tailwater stage at S-34 in the NNRC is less than 6.0 NGVD and the tailwater stage at S-142 is less than 10.0 ft NGVD.

S-143 is a gated culvert through L-35B, in the alignment of the North New River Canal (NNRC) at the point the levee crosses the canal. It has two functions: (1) to supply water to the NNRC basin during periods of low natural flow, and (2) when the stage in WCA 2A is above the regulation schedule, to discharge water from the

WCA to tidewater by way of the NNRC. S-143 is one of two structures that can be used to supply water to the NNRC basin. The other is S-141 which can pass water from WCA 2B to the NNRC if the water is available in WCA 2B. Water releases are made at these structures as necessary to maintain a stage in the NNRC at Sewell Lock between 3.5 and 4.5 ft NGVD. Regulatory discharges through S-143 are made only if the water is not needed in WCA 3A, and the tailwater stage at S-34 in the NNRC is less than 6.0 NGVD. No discharges are made at S-143 if the tailwater stage exceeds 10.0 ft NGVD.

Sewell Lock is an eight-bay spillway and lock structure located in the alignment of the NNRC about nine-tenths of a mile west of Florida's Turnpike. Control of water flow is affected by flashboards. The lock is not used. The spillway controls water surface elevations upstream in the NNRC, and it regulates discharges to the South Fork of the New River. In so far as is possible a headwater stage of between 3.5 and 4.5 ft NGVD is maintained by Sewell Lock.

G-123 is a pumping station located on the NNRC adjacent to S-34 and northeast of the intersection of State Road 84 and U.S. Highway 27. It pumps excess water in the NNRC upstream of S-34. This water is subsequently discharged to WCA 3A by way of S-142. Pumping is initiated if the headwater stage at G-123 (i.e., the tailwater stage at S-34 exceeds 3.7 ft NGVD). Pumping is terminated if the headwater stage drops below 3.5 ft NGVD or if the tailwater stage rises above 11.5 ft NGVD.

**Comments on Design and Historic Operation**

The North New River was excavated and extended to drain the Everglades, and to serve as a transportation route between Lake Okeechobee and the east coast. After the District took over management of the canal from the Everglades Drainage District, a study was performed to determine the flood protection provided by the canal. The results of the study indicated that the existing hydraulic cross-section of the NNRC and the capacity of Sewell Lock were adequate for 1-25 year protection, and that a 1-50 year storm would cause some flooding in the western reaches. This was deemed to be adequate protection. The canal has not been enlarged under District management.

The eastern basin drains to the NNRC downstream of Sewell Lock. Approximately two-thirds of the drainage from the eastern basin is pumped into the NNRC. This drainage is from the portion of the eastern basin west of Sewell Lock. The remaining one-third of the eastern basin drains to the NNRC by gravity flow. All of the western basin drains to the NNRC west of Sewell Lock.

The original basin area was approximately 41 square miles. Three modifications to this basin and adjacent basins have reduced the drainage area to approximately 30 square miles. Firstly, the Plantation Drainage District now pumps water from their northeastern corner (formerly in the NNRC basin) to the C-12 basin. Secondly, since runoff from the western C-11 basin is now backpumped to Water Conservation Area 3A, drainage in that area has been improved, and some of the land formerly draining to the NNRC now drains to C-11. Finally, the Department of Transportation removed most of the culverts under State Road 84 (at the District's request), eliminating almost all drainage from the south into the NNRC. Only the developments of Bonaventure and Shenadoah still discharge to the NNRC from the south.

Bonaventure is included in the NNRC basin, but the design criteria for C-11 and for the NNRC were developed assuming the Shenandoah development would discharge its runoff to C-11. Normal drainage from the Shenandoah development is to C-11, but storm runoff is discharged to the NNRC.

In 1973 the District made a hydraulic analysis of the C-13 and the NNRC basins. Since these basins have an open channel connection (i.e., uncontrolled) at the confluence of C-42 and the L-35A borrow canal, it was necessary to verify that design discharges for Sewell Lock (Table 6) on the NNRC and for S-36 on C-13 (Table 4) would result in the same stage at the open channel connection between the basins. The calculation upstream of S-36, west in C-13 and then north in C-42, gave a stage of 7.19 ft NGVD at the open channel connection. The calculation upstream of Sewell Lock, west in the NNRC and then northeast in the L-35A borrow canal, gave a stage of 7.24 ft NGVD at the open channel connection. The design discharges for Sewell Lock and at S-36 were considered to be correct based on this study.

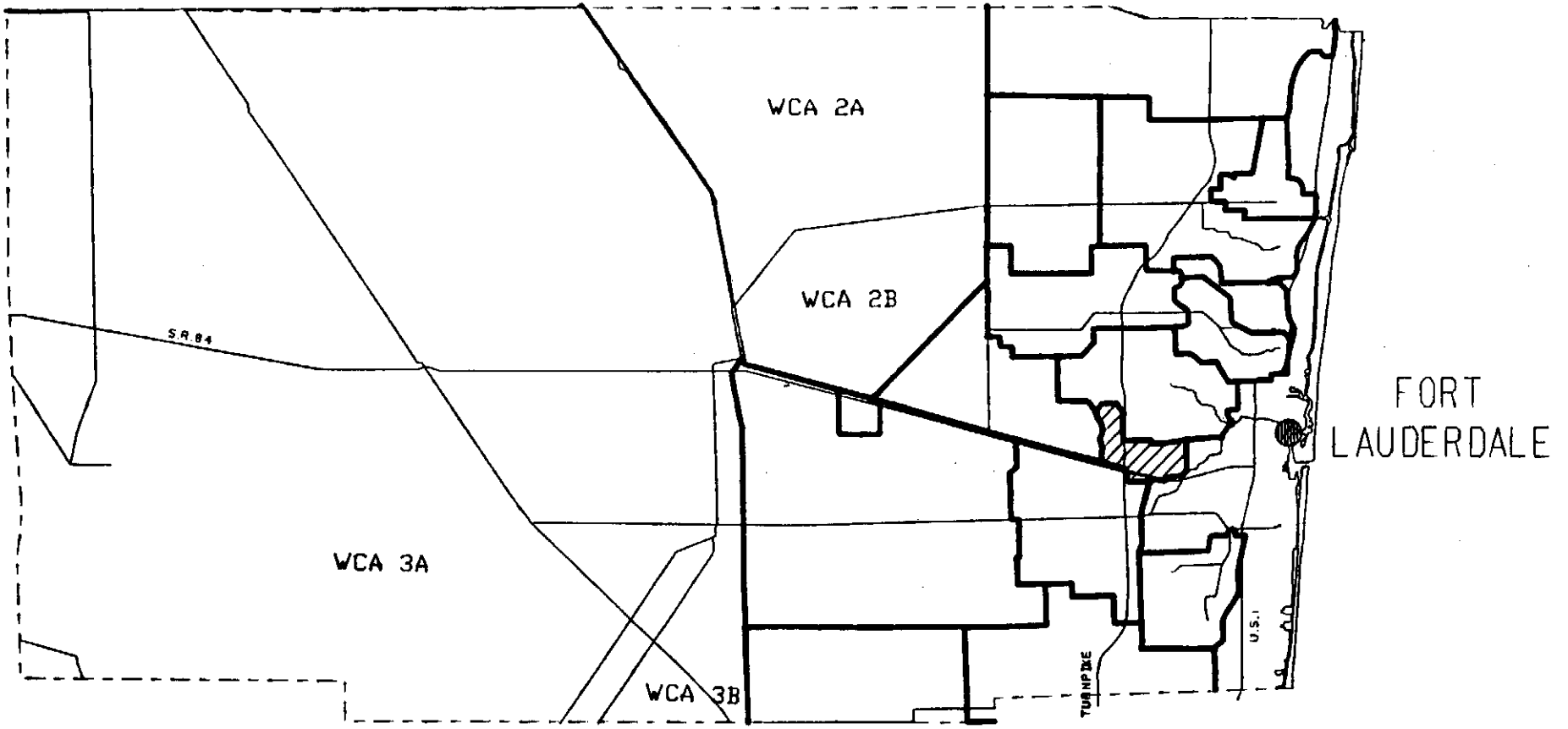



**FIGURE 18 NORTH NEW RIVER CANAL EAST BASIN LOCATION MAP**

# NORTH NEW RIVER CANAL EAST BASIN

## 4,800 ACRES

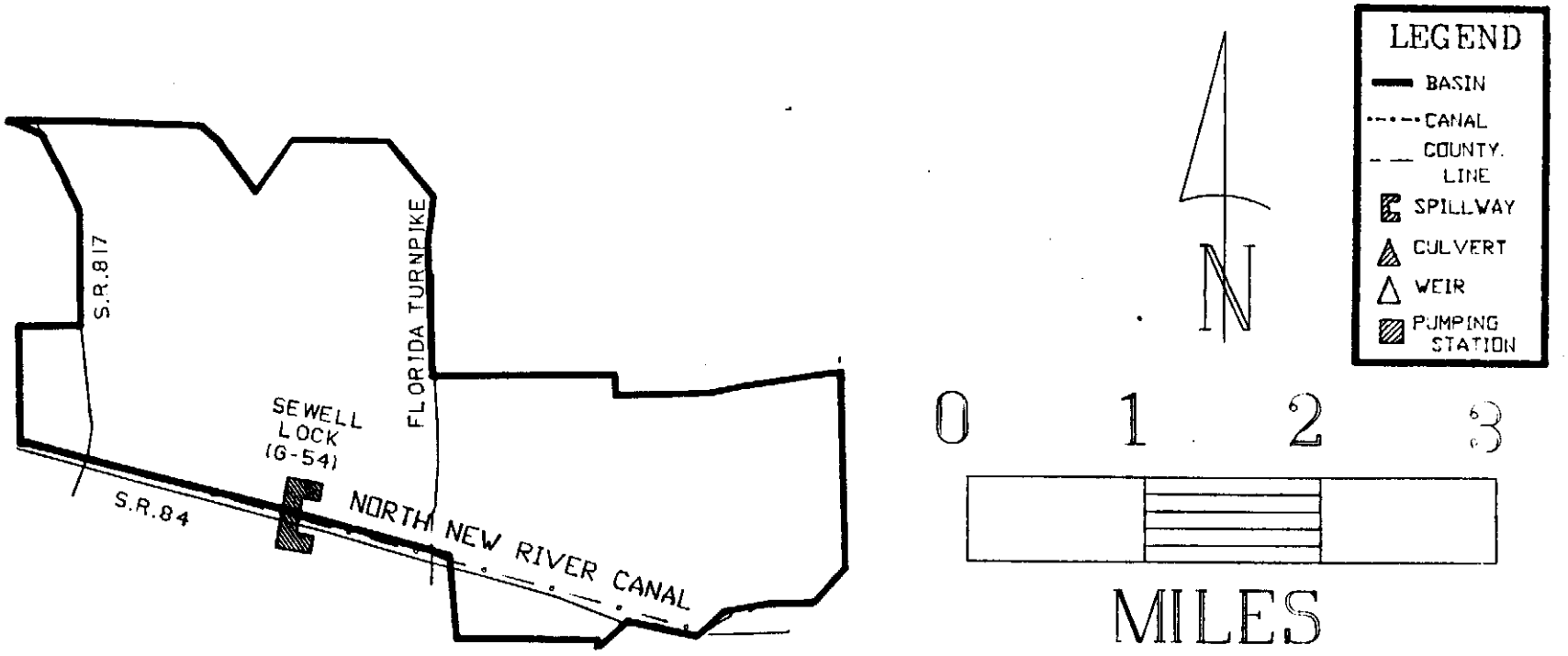



**FIGURE 19 NORTH NEW RIVER CANAL EAST BASIN MAP**

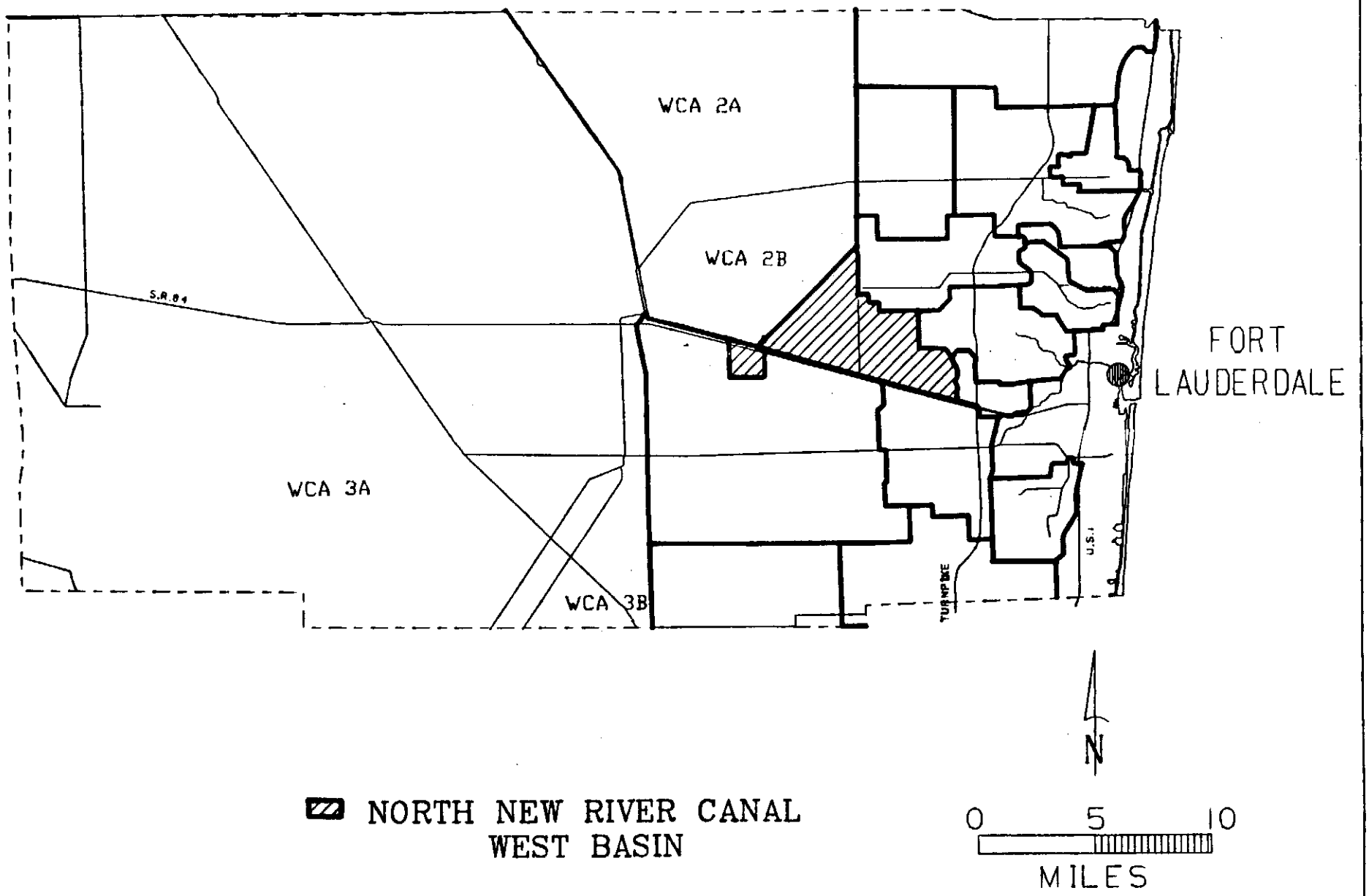



**FIGURE 20 NORTH NEW RIVER CANAL WEST BASIN LOCATION MAP**

# NORTH NEW RIVER CANAL WEST BASIN

## 14,500 ACRES

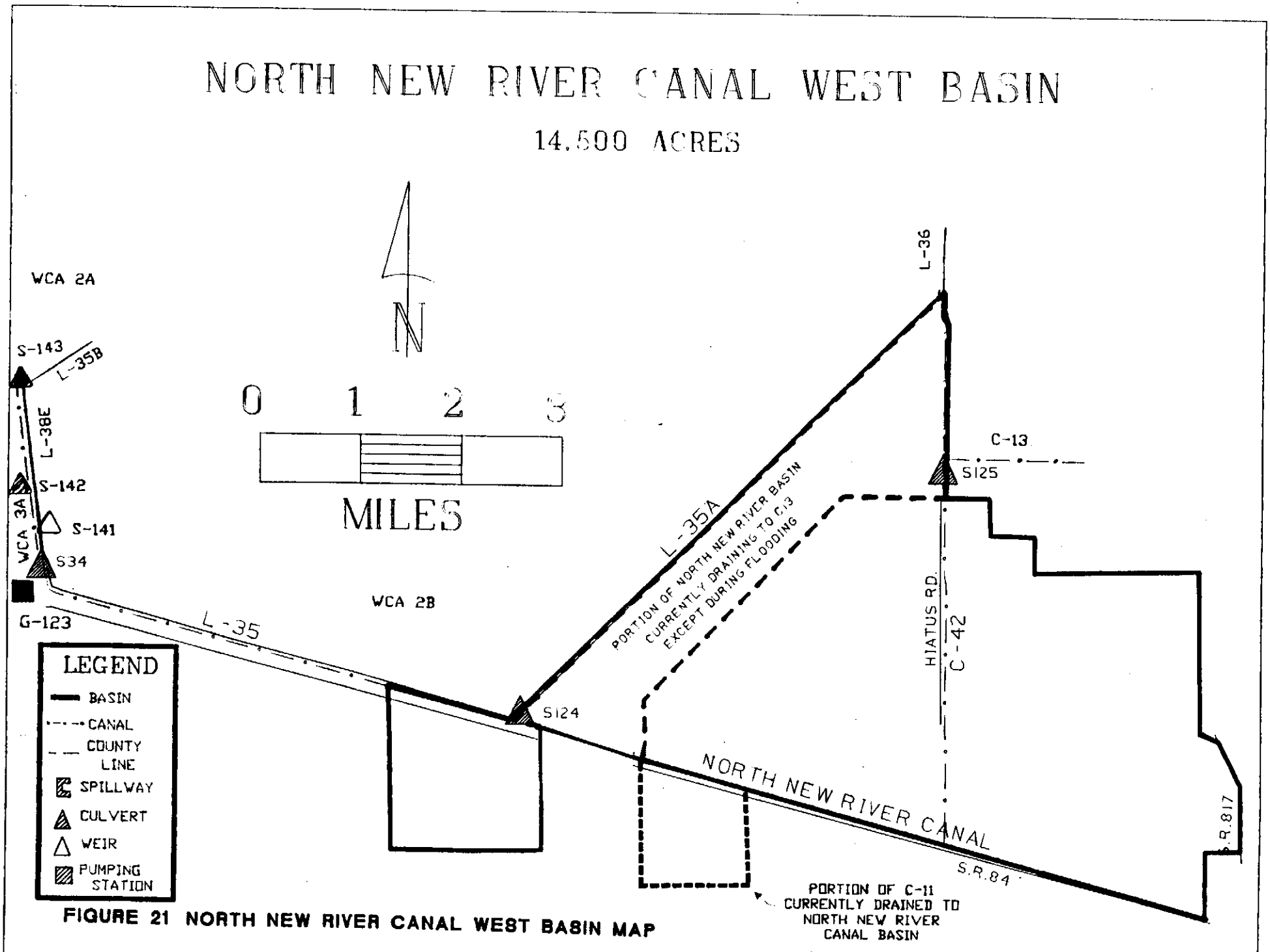



**FIGURE 21 NORTH NEW RIVER CANAL WEST BASIN MAP**

TABLE 6. North New River Canal Basin Structures - Design Criteria

| Structure | Type | Design HW Stage (ft NGVD) | Design TW Stage (ft NGVD) | Optimum Stage (ft NGVD) | Design Q (cfs) | Peak Stage (ft NGVD) and Q (cfs) | Date of Peak Occurrence |
|---|---|---|---|---|---|---|---|
| Sewell Lock (G-54) Stage divide | Flash board spillway 8-Bays Net lgth ~45ft Weir elev = -3.6ft NGVD | 3.5 | 3.0 | HW = 3.5 - 4.5 | 1300 | HW = 5.97 TW = 4.66 Q = 2040 | 4/25/79 4/25/79 6/19/59 |
| S-124 Normal flow-closed Flood conditions-open | Gated Culvert 5-72in x 48ft CMP Invert elev = -1.0ft NGVD | 7.02 | 6.57 | HW = 5.0 - 5.5 | 490 | *HW = 7.8 + TW = 6.86 *HW may have been above 8.0 | 4/25/79 4/25/79 |
| S-34 Water supply to NNR Canal | Gated Culvert 2-72in x 133 ft CMP Invert elev = -3.0ft to -4.0 ft NGVD | 16.9 | 6.0 | HW = ~11-11.5 TW = 3.5 - 4.0 TW = 6.0 max. | 350 | HW = 13.08 TW = 7.05 Q = 728 | 9/29/60 4/26/79 12/1/59 |
| S-125 Divide C-13 and North New River Canal (Regulatory releases to NNRC from C-13) | Gated Culvert 1-48in x 40ft CMP Invert elev = 2.0ft NGVD | 6.5 | 6.0 | HW = 6.0 TW = 3.5 - 4.5 (at Sewell Lock) | 40 (Regulatory releases) | HW = 8 + | 4/25/79 |
| G-123 Pumps from NNRC to WCA-3A | Pumping Station 4 units: 100cfs each | 2.0 | 12.0 | HW = 3.5 HW = 11.0 | 400 | | |
| S-141 Stage Divide | Sheet-pile overflow weir in L-38E Flashboard control crest length = 30.0 ft Crest elev = 7.0 ft NGVD | 10.0 | 8.0 | Regulation schedule in WCA 2B | 435 | | |
| S-142 Stage Divide Water Supply | Gated Culvert 2-72 in x 42 Ft CMP Invert elev = 2.0 ft NGVD | 11.0 | 9.0 | Regulation schedule in WCA 3A | 500 | | |
| S-143 Stage Divide Water Supply | Gated Culvert 2-72 in x 70 ft CMP Invert elev = 2.0 ft NGVD | 13.0 | 10.0 | Regulation schedule in WCA 2A | 500 | | |

in = inches
ft = feet
elev = elevation
lgth = Length
TW = Tail water
Q = discharge in cfs
CMP = Corrugated metal pipe
RCP = Reinforced concrete pipe
ft NGVD = Feet relative to National Geodetic Vertical Datum
HW = Head water
CFS = Cubic feet per second
ds = downstream
ups = upstream

## C-11 (SOUTH NEW RIVER CANAL) BASIN

### Description of the Basin

The C-11 basin has an area of approximately 104 square miles and is located in south central Broward County. The C-11 basin is divided into a western basin (81 square miles, Figure 24) and an eastern basin (23 square miles, Figure 22). The basin boundaries relative to local roads and landmarks are shown on Map A. Schematic maps showing the basin boundaries, canals and control structures are given in Figures 23 and 25.

The Project canals and control structures in the C-11 basin have four functions: (1) to provide flood protection and drainage for the basin, (2) to supply water to the basin during periods of low natural flow, (3) to intercept and control seepage from Water Conservation Area (WCA) 3A, and (4) to maintain a groundwater table elevation west of S-13 adequate to prevent saltwater intrusion into local groundwater. Excess water in the eastern basin is discharged to the east by way of C-11 and S-13 to the South Fork of the New River. Excess water in the western basin is pumped from C-11 into Water Conservation Area (WCA) 3A by way of S-9. If S-13 is not pumping to capacity, additional discharges of excess water from the western basin can be made to the eastern basin by way of S-13A. During periods of low natural flow, water can be supplied from the western basin to the eastern basin by way of S-13A as required to maintain the optimum stage in the eastern reach of C-11. Water supply to the western basin is by way of seepage from WCA 3A to the L-37 borrow canal. The rate of seepage to the L-33 borrow canal is regulated by the stage held in the canal by S-9XS and in the L-37 borrow canal by the stage held in that canal by S-9XN. Drainage to C-11 from the area between L-33, L-37, and U.S. Highway 27 is controlled by G-86N and G-86S. G-87 divides flow in C-11S between the C-11 and the C-9 basins.

There are four Project canals in the C-11 basin: (1) C-11, (2) C-11S, (3) the section of the L-33 borrow canal between C-11 and Hollywood Boulevard, and (4) the L-37 borrow canal. C-11 is aligned east-west parallel to and north of Griffin Road from the L-37 borrow canal on the west to S-13 at U.S. Highway 441. Direction of flow in the reach of the canal in the eastern basin is to the east with discharge to the South Fork of the New River. Direction of flow in the reach of C-13 in the western basin depends on the operation of the control structures S-13A and S-9 located at either end of the reach.

C-11S is aligned north-south parallel to and three-tenths of a mile east of Flamingo Road from G-87 at Sheridan Street on the south to C-11 on the north. The canal is tributary to and makes an open channel connection with C-11. Direction of flow in C-11S is to the north.

The L-33 and L-37 borrow canals make up a continuous canal aligned north-south along the western boundary of the basin. The L-33 borrow canal is south of C-11 and extends to and makes a connection with C-9. The L-37 borrow canal is north of C-11 and extends to but does not make a connection with the North New River Canal. Direction of flow in the L-33 borrow canal depends on the operation of S-9XS, S-30, and S-32 (refer to the C-9 basin description for the location and

operation of S-30 and S-32), and may be either to the north to C-11 or to the south to C-9. Flow in the L-37 borrow canal is to the south to C-11.

There are eight Project control structures regulating flow in the C-11 basin: S-9, S-9XN, S-9XS, S-13, S-13A, G-86N, G-86S, and G-87. Design criteria for the structures in the basin are given in Table 7.

- S-9 is a pumping station located at the west end of C-11. It pumps excess water in the western C-11 basin to WCA 3A. Excess flow is from rainfall runoff and from seepage to the L-37 borrow canal. The pump station can remove up to three-quarters of an inch of runoff per day from the basin and an equivalent amount of seepage. Pumping is initiated if the headwater stage at S-9 exceeds 4.0 ft NGVD. The canal is not drawn down below 0.0 ft NGVD at S-9.

S-9XN is a culvert located in the L-37 borrow canal just north of C-11. Control of water flow is affected by a riser and stop logs. The structure controls the stage held in the L-37 borrow canal. The stage in the canal determines the rate of seepage to the canal from WCA 3A. Excess water in the canal is discharged to C-11 by way of S-9XN.

S-9XS is a culvert located in the L-33 borrow canal just south of C-11. Control of water flow is affected by a riser and stop logs. Along with S-30 and S-32 (refer to the C-9 basin description for location and operation of S-30 and S-32), S-9XS controls the stage held in the L-33 borrow canal. The stage in the canal determines the rate of seepage to the canal from WCA 3A. Occasionally, excess water in the L-33 borrow canal may be discharged to C-11 by way of S-9XS. Usually excess water in the canal is discharged to C-9 by way of S-30.

S-13 is a pumping station and gated spillway located in the alignment of C-11 at U.S. Highway 441. In so far as is possible the gated spillway is operated to maintain a headwater stage of 1.6 ft NGVD. If the headwater stage exceeds 2.5 ft NGVD the pumps are operated to draw the canal down. The pumps can remove up to three-quarters of an inch of runoff from the basin per day in addition to gravity flow through the spillway.

S-13A is a gated culvert located in C-11 just south of the intersection of Golden Shoe Road and Orange Drive. It is normally closed and acts as a divide structure between the eastern and western C-11 basins. It is opened to supply water to the eastern basin from the western basin when natural drainage to the eastern basin is not adequate to maintain the optimum stage in the eastern reach of C-11. It can also be opened to pass flood flows from the western to the eastern basin if S-13 is not pumping to capacity.

G-86N is a gated culvert located in the west drainage ditch of U.S. Highway 27 north of C-11. It controls the stage in the drainage ditch, and it regulates discharge of runoff from the area between L-37 and the highway to C-11. The stop logs are normally set to maintain a stage of 5.5 ft NGVD in the drainage ditch.

G-86S is a gated culvert located in the west drainage ditch of U.S. Highway 27 south of C-11. It controls the stage in the drainage ditch, and it regulates discharge of runoff from the area between L-33 and the highway to C-11. The stop logs are normally set to maintain a stage of 5.5 ft NGVD in the drainage ditch.

G-87 is a gated culvert located at the south end of C-11S just south of Sheridan Street. It is normally closed and acts as a divide between C-11S (C-11 basin) and the Snake Creek Canal (C-9 basin).

**Comments on Design and Historic Operation**

The C-11 system was designed to provide flood protection of up to three-quarters of an inch of runoff per day from the western basin. The S-9 pump station was designed with a capacity of 2870 cfs. 1650 cfs was for flood protection (adequate to handle the design runoff) and 1220 cfs was for seepage removal (seepage to the borrow canals of L-33 and L-37 from Water Conservation Area 3A).

In the early 1970's a feasibility study by the U. S. Army Corps of Engineers indicated that a positive cost benefit ratio existed for increasing the flood protection for the western basin to 2.5 inches of runoff per day. However, a predicted decline in water quality for the area as a result of the increased runoff has prevented the implementation of the proposal.

A District study conducted in 1972 indicated that seepage into the basin from Water Conservation Areas 3A and 3B was only 350 cfs, not the 1220 cfs of seepage allowed for in the design of S-9. This low seepage amount left 2520 cfs of the total capacity of S-9 (2870 cfs) available for flood control. 2520 cfs of flow would provide flood protection of 1.25 inches of runoff per day. Since C-11, as designed and built, cannot pass 2520 cfs of flow, C-11 must be enlarged if it is to take advantage of the actual capacity of S-9 for runoff removal. New cross-sections for C-11 have been designed for S-9 discharging 2520 cfs of runoff. The design calls for enlarging C-11 from S-9, east to the junction of C-11 and C-11S. C-11 has been enlarged to the new design cross-section, or greater, for the four miles of canal just east of S-9. The rest of C-11 in the western basin, east to its confluence with C-11S, has not been excavated except for 4500 ft near the I-75 crossing of C-11. When I-75 was constructed, C-11 was rerouted to the borrows of the entrance and exit ramps north of Griffin Road. The borrows were excavated to the specifications of the new design cross-sections. 6000 feet of C-11 west of I-75 and 10700 feet east of I-75 have not been enlarged to the new hydraulic section.

The pumping station at S-13 was designed to provide the eastern basin with flood protection of up to three-quarters of an inch of runoff per day. Depending on the headwater and tailwater stages at the S-13 spillway, gravity flow from the eastern C-11 basin to the east may provide additional flood protection of up to three-quarters of an inch of runoff per day.

The optimum headwater stage at S-13 is 2.25 ft NGVD. This stage prevents flooding in low-lying residential areas and citrus groves in the eastern basin. The April 25, 1979 storm had a peak discharge of 1050 cfs at S-13. This is approximately 1.6 inches of runoff per day from the basin. Roads, citrus groves, pastures and at least one home were flooded in the eastern basin.

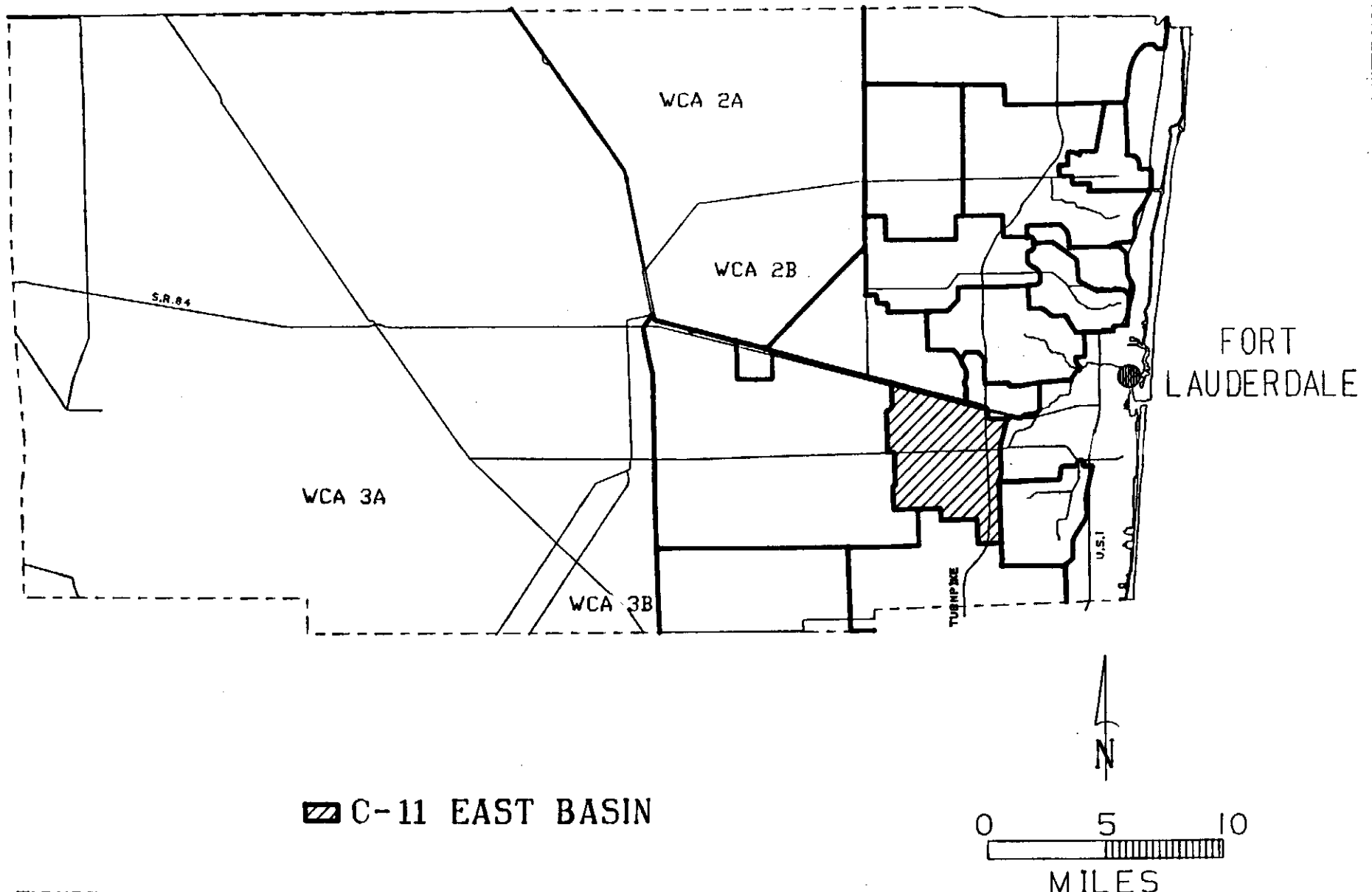



**FIGURE 22 C-11 EAST BASIN LOCATION MAP**

# C-11 EAST
## 15.000 ACRES

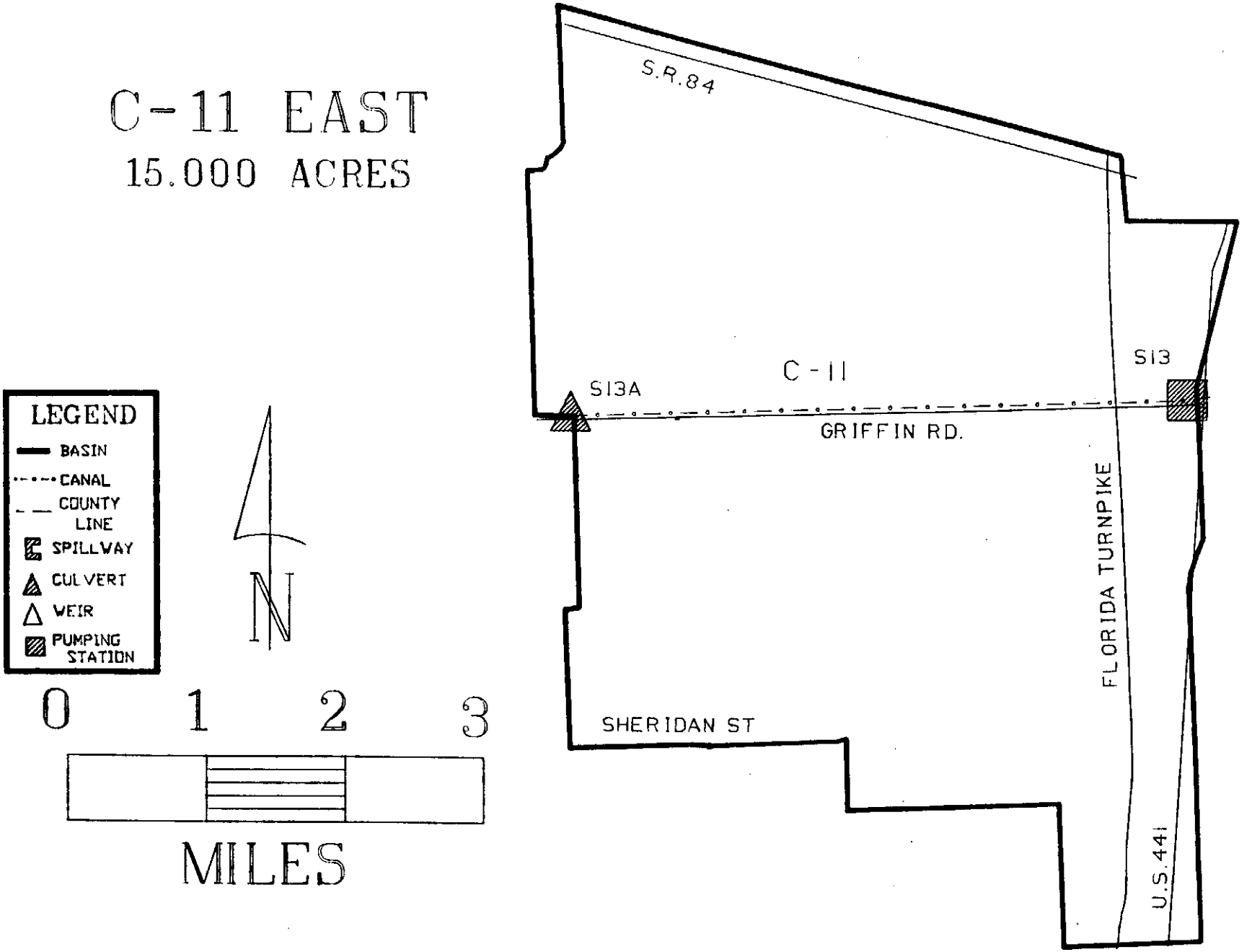



**FIGURE 23 C-11 EAST BASIN MAP**

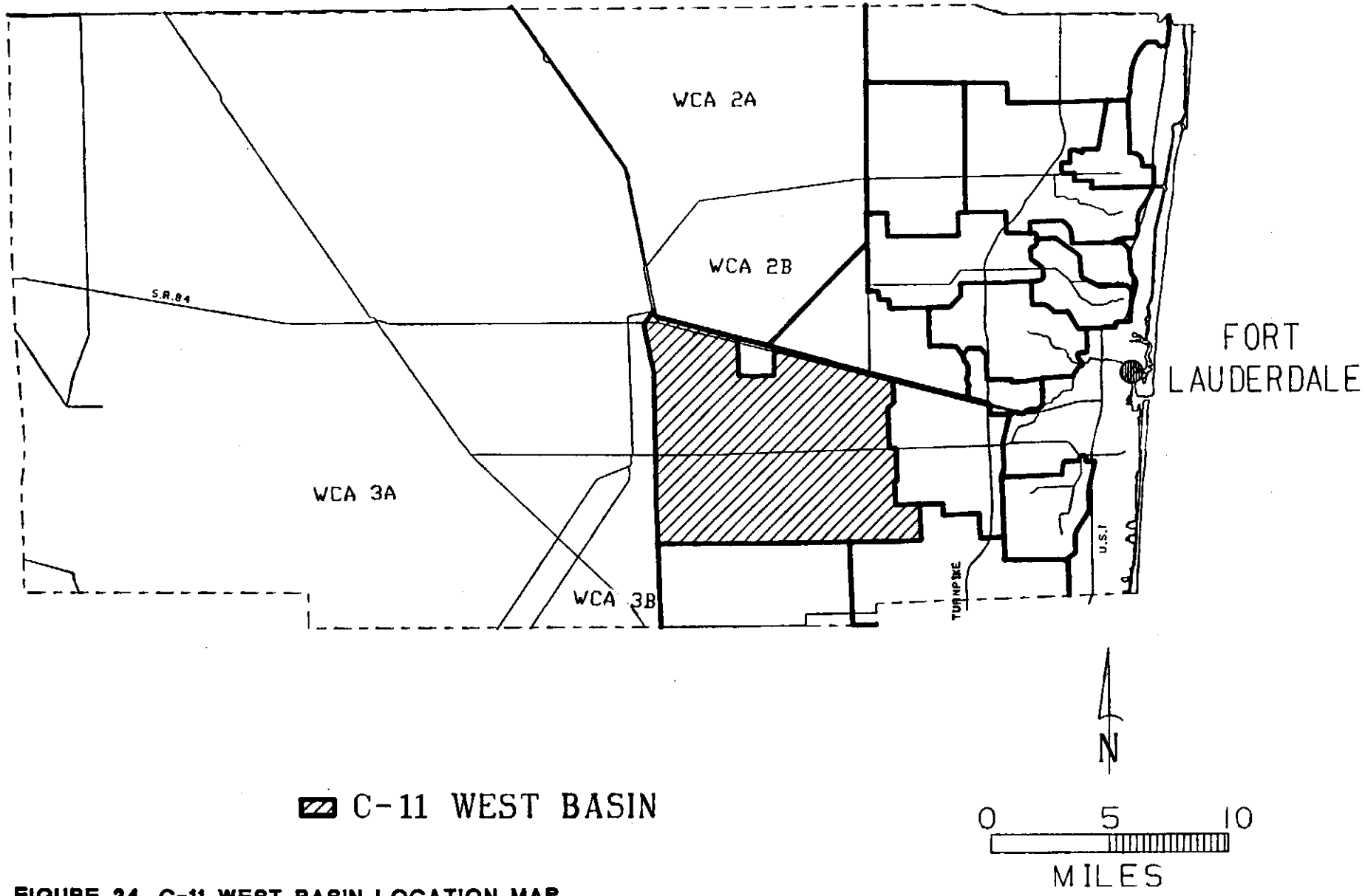



**FIGURE 24 C-11 WEST BASIN LOCATION MAP**

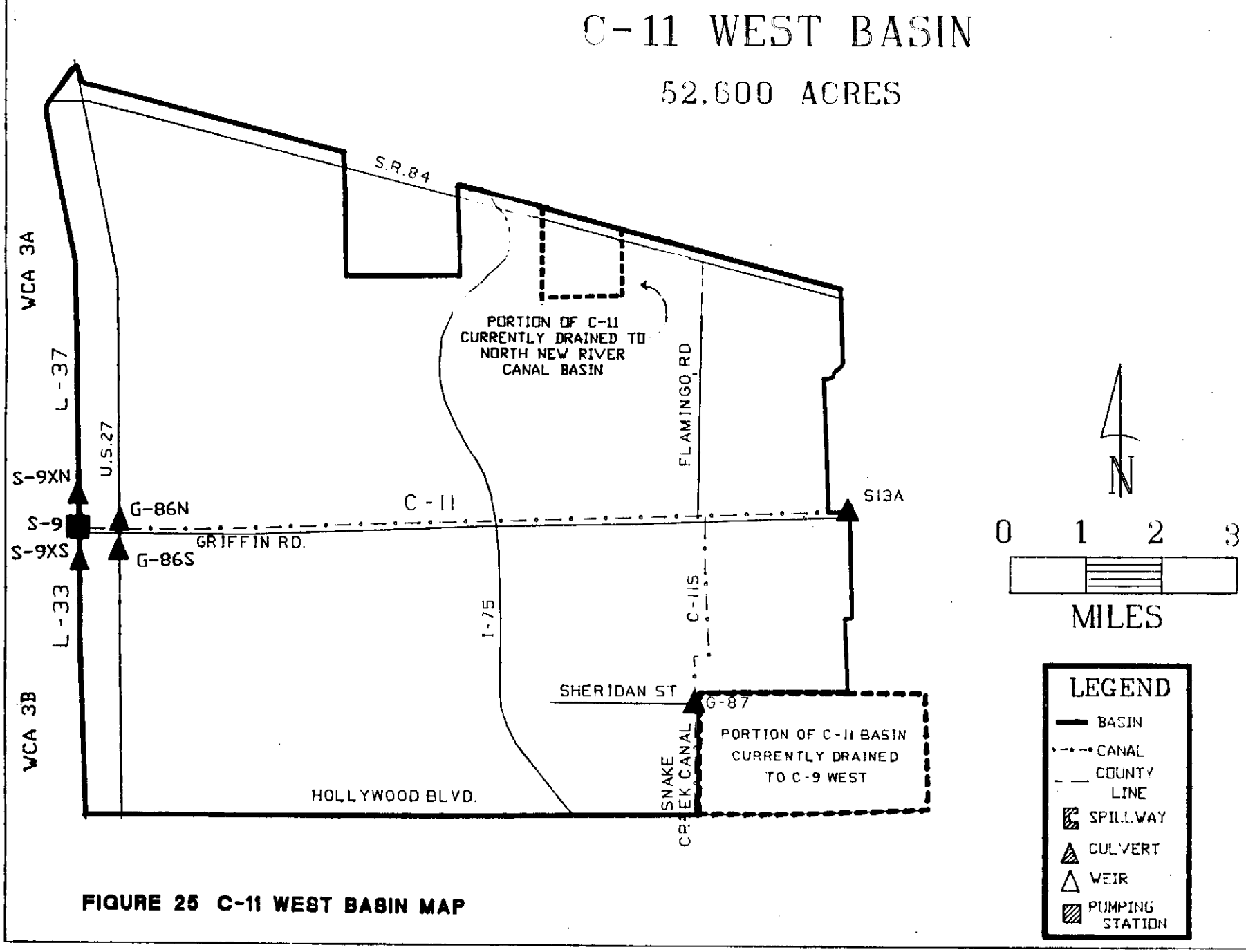



**FIGURE 25 C-11 WEST BASIN MAP**

TABLE 7. C-11 Basin Structures - Design Criteria

| Structure | Type | Design HW Stage (ft NGVD) | Design TW Stage (ft NGVD) | Optimum Stage (ft NGVD) | Design Q (cfs) | Peak Stage (ft NGVD) and Q (cfs) | Date of Peak Occurrence |
|---|---|---|---|---|---|---|---|
| S-13<br>Stage divide | Pump and spillway,<br>3 units, 180cfs each<br>1-16ft x 11.3ft gate<br>Weir lgth = 16.0ft<br>Weir crest elev = -8.0ft NGVD | 1.2 (gravity)<br>2.2 - 2.5 (pump) | 1.0 (gravity)<br>6.2 - 6.5 (pump) | HW = 1.6 (gravity)<br>HW = 2.2 (gravity) | 540 (gravity)<br>540 (pumped) | HW = 4.02<br>TW = 4.85<br>Q = 1050 | 4/25/79<br>4/25/79<br>4/25/79 |
| S-13A<br>Divide structure during flooding | Gated Culvert<br>2-72in x 66ft CMP<br>2-54in x 60ft CMP | 2.5 | 2.0 | 3.0 to west | 120 | HW (west) 6.27<br>TW (east) 4.79 | 4/25/79<br>4/25/79 |
| S-9 | Pump, 3 units<br>960cfs each | 4.0 | 14.4 | HW = 3.0 - 3.5 | 2880 | Intake = 6.1<br>Q = 2060 | 4/25/79<br>8/18/81 |
| S-9XS<br>Stage Divide | Culvert<br>with risers and stop logs<br>2-72in x 42ft CMP<br>Invert elev = -1.0ft NGVD | | | HW = 6.8 | | | |
| S-9XN<br>Stage Divide | Culvert<br>with risers and stop logs<br>2-72in x 84ft CMP<br>Invert elev = -4.8ft NGVD | | | HW = 6.0 | | | |
| G-86S<br>Stage Divide | Culvert<br>with risers and stop logs<br>1-60in x 135ft CMP<br>Invert elev = -1.14ft NGVD | | | HW = 5.5 | | | |
| G-86N<br>Stage Divide | Culvert<br>with risers and stop logs<br>1-60in x 135ft CMP<br>Invert elev = -1.0ft NGVD | | | HW = 5.5 | | | |
| G-87<br>(Presently used as a drainage divide between C-11 and C-9 basins) | Gated Culvert<br>1-84in x 75ft CMP<br>Invert elev = -5.0ft NGVD | | | | (Divide structure) | | |

in = inches
ft = feet
elev = elevation
lgth = Length
TW = Tail water
Q = discharge in cfs
CMP = Corrugated metal pipe
RCP = Reinforced concrete pipe
ft NGVD = Feet relative to National Geodetic Vertical Datum
HW = Head water
CFS = Cubic feet per second
ds = downstream
ups = upstream

## C-10 (HOLLYWOOD CANAL) BASIN

### Description of the Basin

The C-10 basin has an area of approximately 15 square miles and is located in southeast Broward County (Figure 26). The basin boundary relative to local roads and landmarks is shown on Map A. A schematic map showing the basin boundary and canals is given in Figure 27.

The Project canals in the C-10 basin provide flood protection and drainage for the C-10 basin. There is no regulation of water surface elevations and discharge from the basin is not controlled. Water supply to the basin is from local rainfall.

There are two Project canals in the C-10 basin: C-10 and the C-10 Spur Canal.

C-10 begins at Johnson Road one-quarter mile west of I-95. It extends to the north connecting to the Dania Cut-off Canal 2.6 miles west of the Intracoastal Waterway. Flow in the canal is to the north.

The C-10 Spur Canal begins one-quarter mile north of Sheridan Street and 1.6 miles west of I-95. It extends to the east connecting to C-10 six-tenths of a mile north of Sheridan Street. Flow in the canal is to the east.

There are no Project control structures in the C-10 basin.

### Comments on Design and Historic Operation

C-10 was designed to pass the Standard Project Flood (SPF). The SPF design stage at the confluence of C-10 with the Dania Cut-off Canal is 4.7 ft NGVD. The maximum SPF design stage in C-10 is 5.6 ft NGVD near the Johnson Street Bridge. Stage and discharge data were collected for the period April 1962 to September 1967 at the Tigertail Road Bridge. The peak stage of 3.82 ft NGVD occurred on September 8, 1965. The peak discharge was 470 cfs on October 31, 1965. The only high water stage available for the April 25, 1979 storm (maximum rainfall at the Hollywood Water Plant was 12.56") was 8.3 ft NGVD recorded at N.W. 46th Avenue and Sheridan Street. This was 1.3 feet above an estimated 100 year flood stage of 7.0 ft NGVD for the area. This estimate of the 100 year flood stage was based on information from a map furnished by the Broward County Water Control Division.

C-10 was constructed without a control structure to maintain the water surface elevation in the canal high enough to prevent salt water intrusion into local groundwater. Since there is no water supply to C-10 from outside the basin, it would be impossible to maintain the required water surface elevation in the canal during periods of low flow even if a structure was in place.

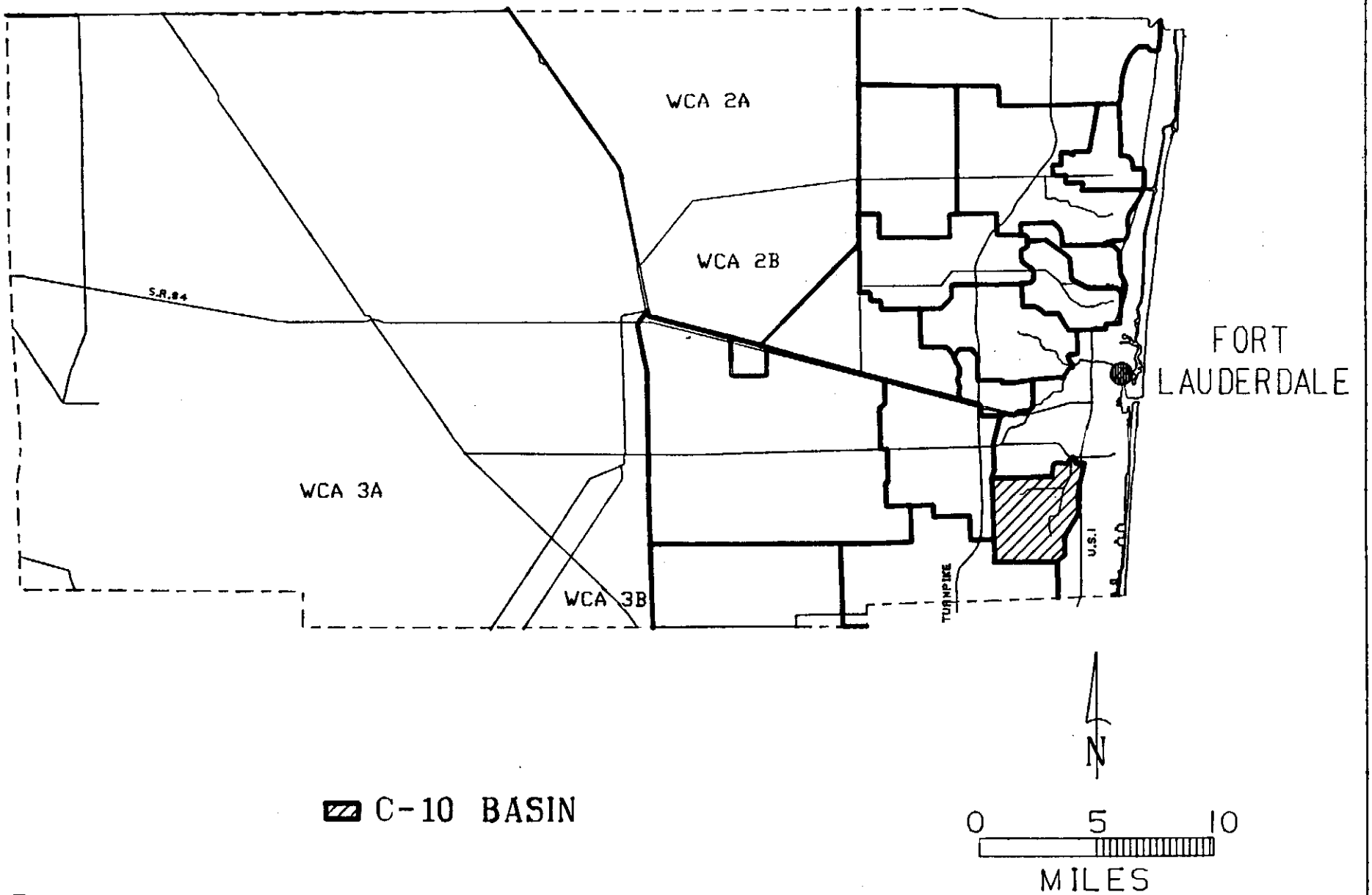



**FIGURE 26 C-10 BASIN LOCATION MAP**

# C-10 BASIN
# (HOLLYWOOD CANAL)
## 9,500 ACRES

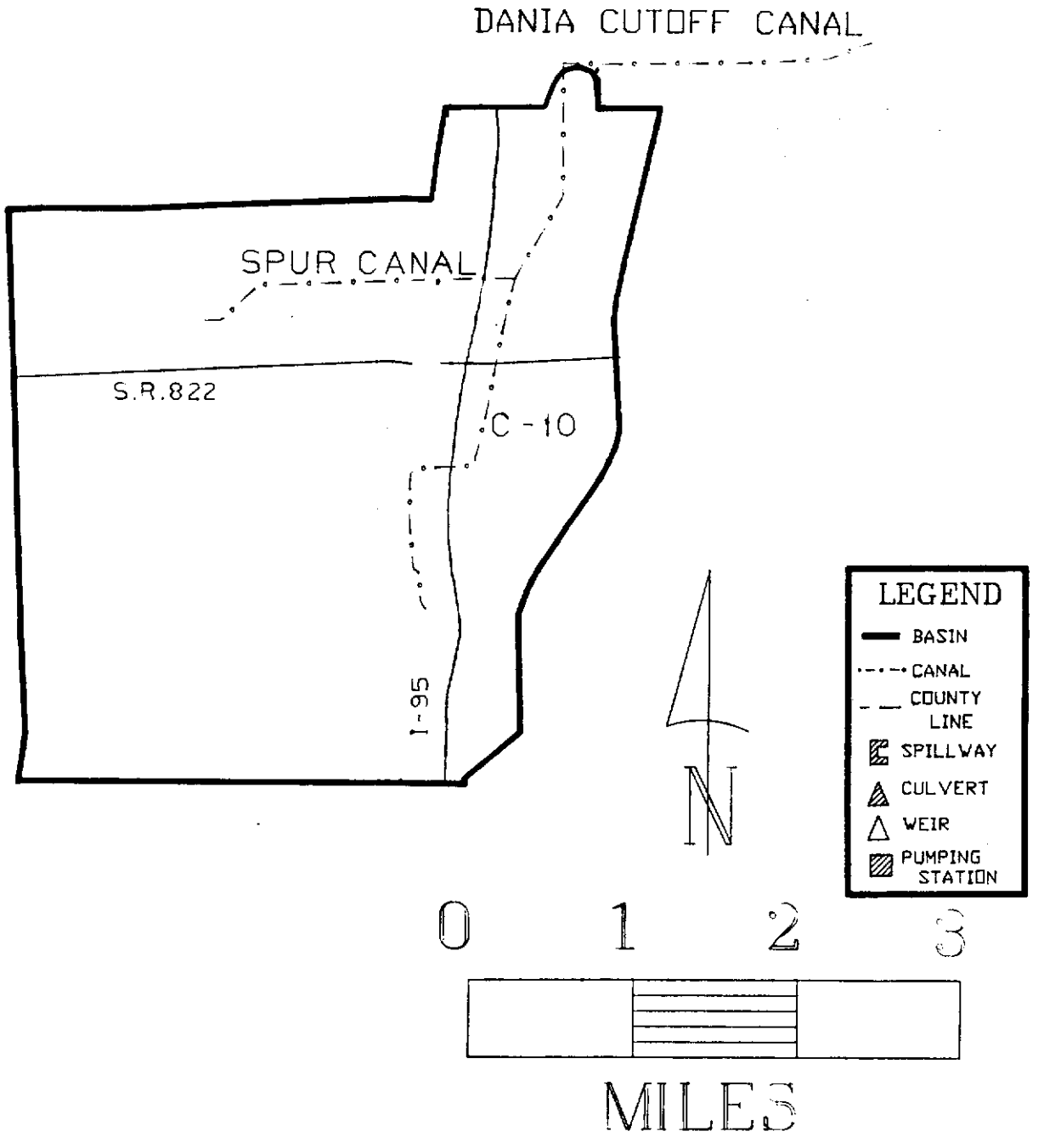



**FIGURE 27 C-10 BASIN MAP**

## C-9 (SNAKE CREEK CANAL) BASIN

### Description of the Basin

The C-9 basin has an area of approximately 98 square miles and is located in northeastern Dade County (39 square miles) and southeastern Broward County (59 square miles, Figures 28 and 30). The basin is comprised of two subbasins, C-9 east (45 square miles) and C-9 west (53 square miles). The boundary between the subbasins is Flamingo Road in Broward County and N.W. 67th Avenue in Dade County. The subbasin boundaries relative to local roads and landmarks are shown on Map A. Schematic maps showing the basin boundaries, canals, and control structures are given in Figures 29 and 31.

The Project canals and control structures in the C-9 basin have four functions: (1) to provide flood protection and drainage for the basin, (2) to supply water to the C-9 basin for irrigation and municipal water supply during periods of low natural flow, (3) to intercept and control seepage from Water Conservation Area 3B, and (4) to maintain a groundwater table elevation west of S-29 adequate to prevent saltwater intrusion into local groundwater. Excess water in the basin is discharged to tidewater by way of C-9 and S-29. S-29 also regulates water surface elevations in C-9. Seepage from WCA 3B intercepted by the L-33 borrow canal is the primary source of water supplied to the C-9 basin. The rate of seepage from the WCA is controlled by the stage maintained in the borrow canal by S-30, S-32, and S-9XS (refer to the C-11 basin description for location and operation of S-9XS). During the dry season, when the rate of seepage to the L-33 borrow canal may be reduced because of low water in WCA 3B, water can be supplied to the C-9 basin from C-6 by way of S-32 and the L-33 borrow canal. When drainage to C-9 is more than adequate to maintain the optimum stage in the canal, excess water from rainfall and seepage can be stored in the area between L-33 and U.S. Highway 27. This water can be released to C-9 through S-30 as needed for water supply during the dry season.

There are two Project canals in the C-9 basin: C-9 and the L-33 borrow canal.

C-9 is aligned east-west extending from L-33 on the west to Dumfoundling Bay on the east. C-9 makes an open channel connection with the L-33 borrow canal one mile north of the intersection of L-30 and L-33 and one-half mile west of U.S. Highway 27. Flow in C-9 is to the east with discharge by way of S-29 to Dumfoundling Bay.

The L-33 borrow canal is aligned north-south along the western boundary of the C-9 basin. It makes an open channel connection to the west end of C-9 and is connected to C-6 by way of S-32. Flow in the borrow canal depends on the operation of S-30, S-32, and S-9XS (refer to the C-11 basin description for location and operation of S-9XS), and may be either to C-9 or to C-11.

There is one small non-Project canal of interest. The Flamingo Road Canal is aligned north-south, west of and parallel to Flamingo Road. It makes an open channel connection with C-9. Normal flows in this canal are to the south to C-9. Flows of 110 to 140 cfs are pumped to this canal from a portion of the C-11 basin in

the Pembroke Pines area. Without pumping, the runoff from the Pembroke Pines area would flow north to C-11S. Of the flow entering C-9 from the Flamingo Road Canal, 40-50 cfs may subsequently be diverted to C-8 by way of the west borrow canal of N.W. 67th Avenue.

There are three control structures in the C-9 basin: S-29, S-30, and S-32. Design criteria for the structures in this basin are given in Table 8.

S-29 is a gated spillway located in the alignment of C-9 just east of U.S. Highway 1. It controls water surface elevations in C-9, and it regulates discharges to tidewater. In so far as is possible, normal operation of S-29 is to maintain a headwater stage of 2.0 ft NGVD. To protect lands in the western basin from flooding, the operation of S-29 is modified when high stages occur at S-30 at the west end of the canal. If the tailwater stage at S-30 rises above 3.3 ft NGVD, water releases are initiated at S-29 at the direction of the Chief of Operations for the District. When the stage at S-30 drops below 3.0 ft NGVD, S-29 is operated in so far as is possible to maintain a headwater stage at S-29 of 1.2 ft NGVD. When the tailwater stage at S-30 drops below 2.75 ft NGVD, normal operation at S-29 is resumed. The headwater stage at S-29 is usually adequate to prevent intrusion of saltwater into local groundwater and to provide for recharge of well fields near C-9.

S-30 is a gated spillway located in the alignment of C-9 on the west side of U.S. Highway 27. S-30, S-32, and S-9XS (in the C-11 basin) control the stage held in the L-33 borrow canal in order to regulate the rate of seepage from WCA 3B. If the tailwater stage at S-30 is above 3.0 ft NGVD, S-30 is closed to prevent aggravation of downstream flooding conditions in C-9. If the tailwater stage at S-30 is below 3.0 ft, S-30 is operated to maintain a headwater stage of 6.0 ft NGVD at S-30 and S-32. S-30 may be opened to supply water to the C-9 basin as necessary to maintain the optimum stage at S-29.

S-32 is a gated culvert located in the alignment of the L-33 borrow canal just north of C-6. S-30, S-32, and S-9XS (in the C-11 basin) control the stage held in the L-33 borrow canal in order to regulate the rate of seepage from WCA 3B. S-32 is closed during flood conditions to prevent aggravation of downstream flooding conditions in C-6, otherwise S-32 is operated to maintain a stage of 6.0 ft NGVD in the L-33 borrow canal. S-32 may be opened to supply water from C-6 to the C-9 basin as necessary to maintain the optimum stage at S-29.

**Comments on Design and Historic Operation**

C-9 in the eastern subbasin was designed to pass 100 percent of the Standard Project Flood. This provides for essentially unlimited inflows to C-9 from the eastern subbasin. The western subbasin is very prone to flooding because of low ground surface elevations relative to the eastern subbasin. Major storms can reverse flow in C-9 from east to west because of rapid runoff into the eastern reaches of C-9. Allowable pumped inflow to C-9 in the western subbasin is limited to 0.75 inches of runoff per day. Unlimited gravity inflow to C-9 is allowed in the western basin if development limitations are met.

Seepage from Water Conservation Area 3B is a major contributor to flows in C-9. Contributions can be as high as 250 cfs. Average daily discharges from C-9 range from 191 cfs in January to 416 cfs in September.

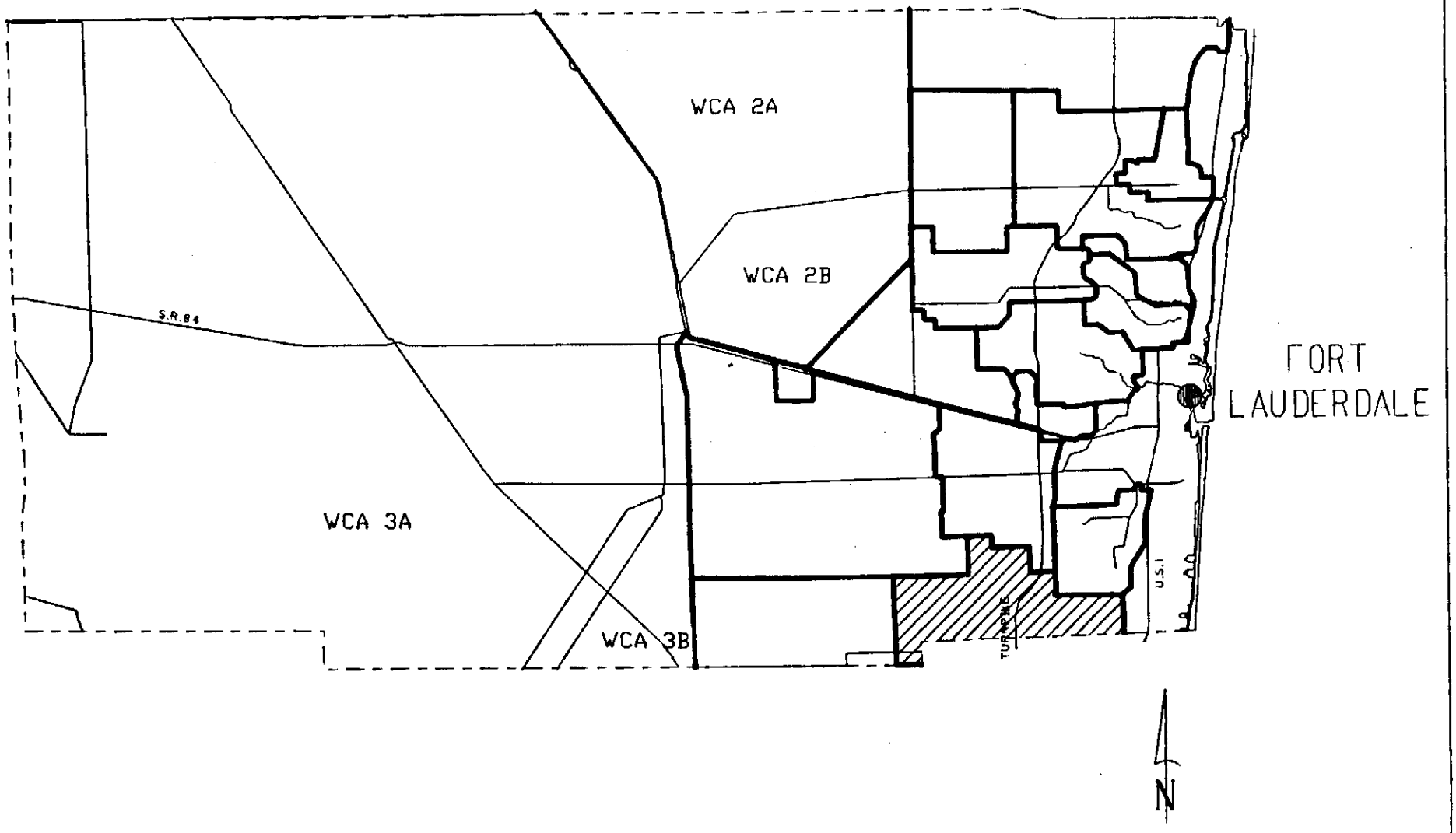



**FIGURE 28 C-9 EAST BASIN LOCATION MAP**

# C-9 EAST BASIN

34.000 ACRES

16.000 ACRES BROWARD

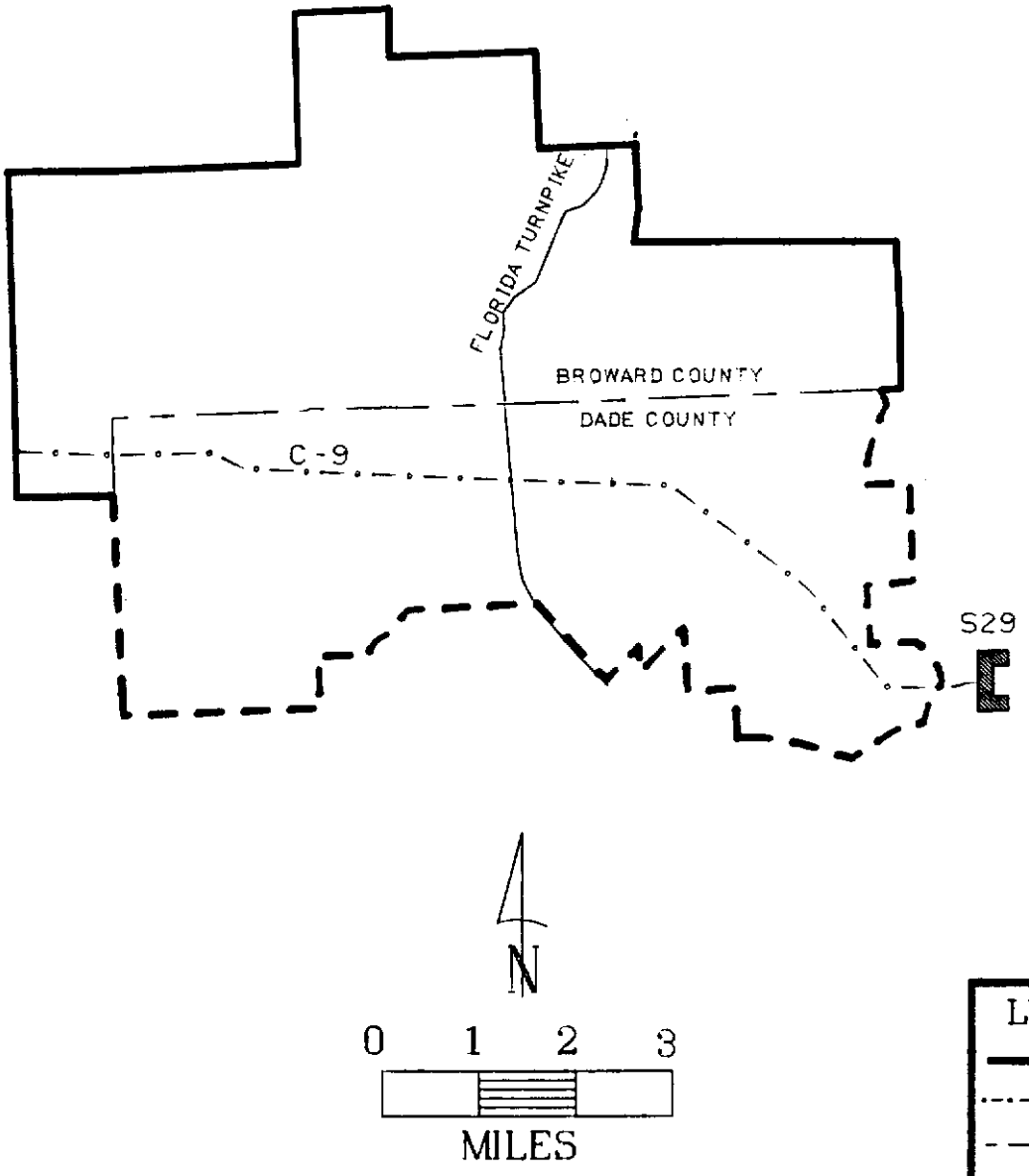



**FIGURE 29 C-9 EAST BASIN MAP**

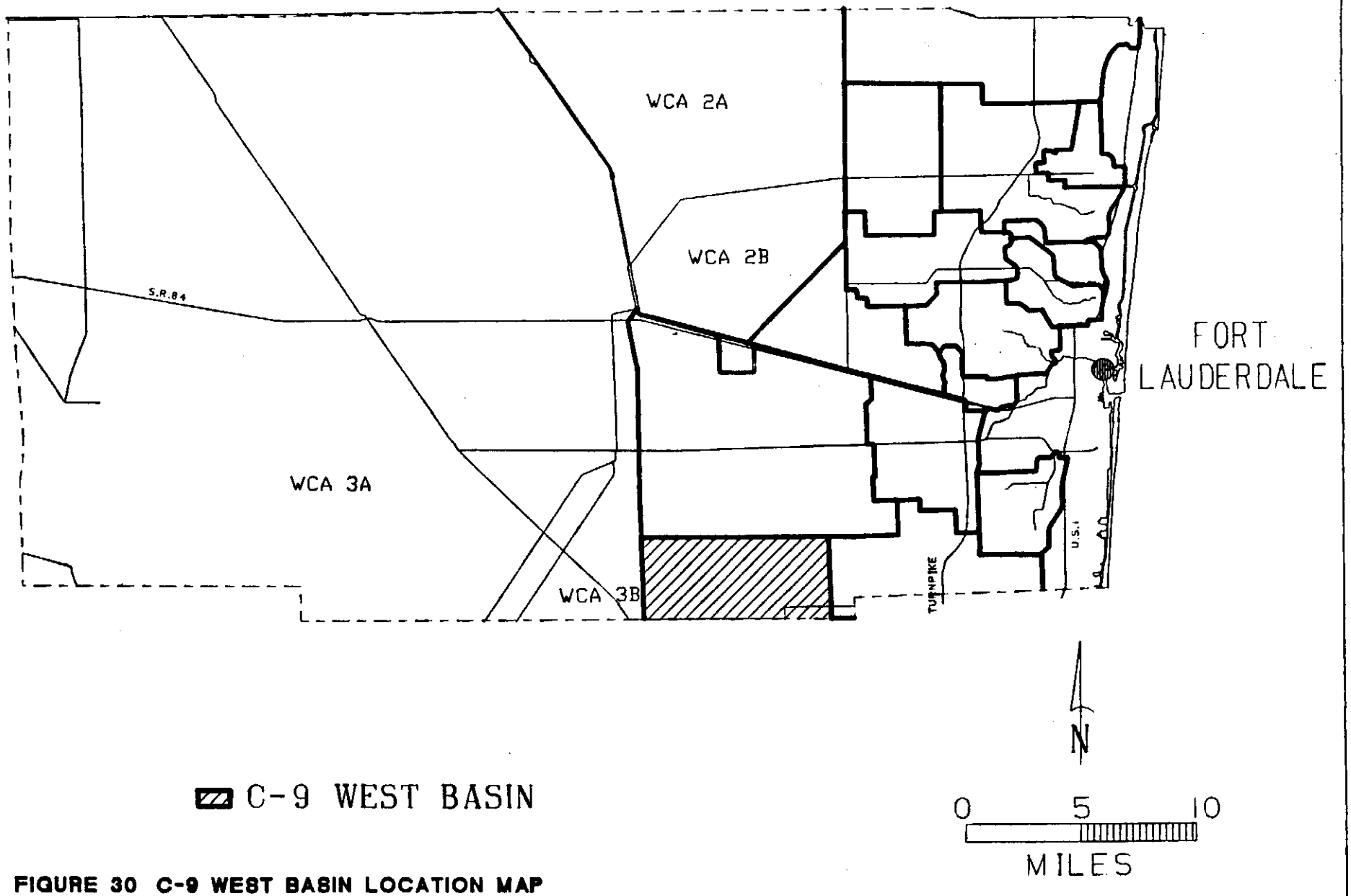



**FIGURE 30 C-9 WEST BASIN LOCATION MAP**

# C-9 WEST

## 29.000 ACRES

18.000 ACRES BROWARD

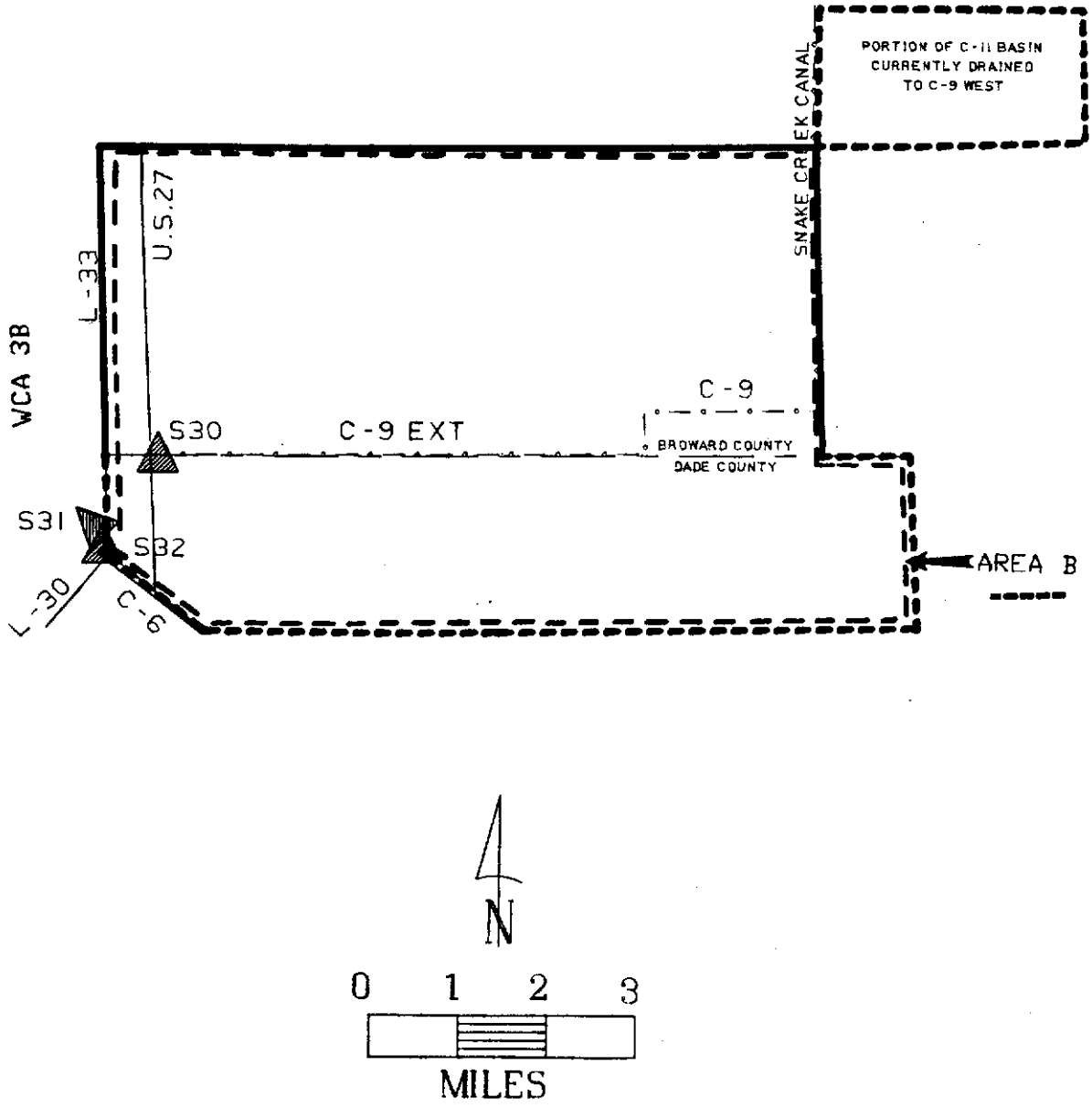



**FIGURE 31 C-9 WEST BASIN MAP**

TABLE 8. C-9 Basin Structures - Design Criteria

| Structure | Type | Design HW Stage (ft NGVD) | Design TW Stage (ft NGVD) | Optimum Stage (ft NGVD) | Design Q (cfs) | Peak Stage (ft NGVD) and Q (cfs) | Date of Peak Occurrence |
|---|---|---|---|---|---|---|---|
| S-29 Stage Divide | Spillway, 4 gates, 22ft x 15ft Crest lgth = 88ft Crest elev = -11.0ft NGVD | 3.0 | 2.5 | HW = ~2.0 | 4780 | HW = 3.88 Q = 4100 | 9/8/65 9/19/64 |
| S-31 Controls outflows from CA-3B to C-6 | Gated Culvert 3-84inx172ft CMP Invert elev = -3.0ft NGVD | 6.0 | 4.0 | | 700 | TW = 6.59 Q = 1090 | 7/1/82 3/20/70 |
| S-30 Controls water stored between L-30 and SR 27 | Gated Culverts 3-84in x 288ft Invert elev = -5.0ft NGVD | | | HW = 6.0 | 560 | | |
| S-32 Water supply to C-9 | Gated Culvert 2-72 in x 40 ft CMP Invert elev = -2.0ft NGVD | 2.5 | ~1.60 | TW = 2.0 HW = 6.0 | 2 | HW = 6.59 | 7/1/82 |

in = inches
ft = feet
elev = elevation
lgth = Length
TW = Tail water
Q = discharge in cfs
CMP = Corrugated metal pipe
RCP = Reinforced concrete pipe
ft NGVD = Feet relative to National Geodetic Vertical Datum
HW = Head water
CFS = Cubic feet per second
ds = downstream
ups = upstream

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## APPENDIX 1 - BASIC CONCEPTS

**Runoff and Drainage** - Several things can happen to rain after it falls to earth. At the beginning of a rain event, the rain will most likely seep into, or "infiltrate", the soil. As soil becomes saturated, however, the rain will tend to pool on the surface of the ground in puddles or ponds. These detention areas have only a limited storage volume, and when their capacity is exceeded, the excess water will flow downhill to the nearest stream or canal. That part of the rainfall that "runs off" of the soil surface to enter local streams is termed "surface runoff". Of the water that is detained on the surface, some will evaporate and the balance will eventually seep into the ground.

Water seeping into the ground enters a reservoir of subsurface water known as groundwater. Since, in south Florida, many soils are very sandy and underlying rock strata tend to be very porous, water flows easily between surface water and groundwater. The surface of the groundwater is known as the "water table". When the water table level is higher than local surface water levels, water will enter the surface water from groundwater. When the water table is lower than the local surface water level, flow is from surface water to groundwater. In general, groundwater supplements stream flow during periods of low rainfall, and surface water recharges groundwater storage during periods of high rainfall. Although subsurface flow from groundwater to surface water is important to the long term supply of water to a canal or stream (it is sometimes referred to as "base flow"), it does not make significant contributions, if at all, to streamflow during storm events with high rainfall.

In the context of these basin descriptions, the term drainage is used to refer to the total surface and subsurface flows entering a canal from its drainage basin. It may be useful to keep in mind, however, that during a rain event (especially one severe enough to cause flooding), it is surface runoff that is the important contributor to this flow, and at times between rain events, subsurface flow from groundwater to surface water is most important.

Runoff from an area is influenced by several factors: how much rain has fallen recently, the depth to the water table, and how the land in the area is used. The amount of recent rain, and the depth to the water table dictate how much water is in the soil. The degree to which the soil is saturated, in turn, determines how much of the falling rain may infiltrate the soil, and thus, how much of the rain will run off to local streams.

Land use has a large impact on the amount of surface runoff entering local streams and canals. For example, most of the surface area in an urban area (e.g., roofs, roads, and parking lots) is impervious to water. Almost all the rain impacting these areas becomes surface runoff. Some water may be detained and will evaporate, but the percentage of rainfall that enters local canals or streams by surface flow in an urban area can be quite high. As a result, urban areas are subject to high stream flows (flooding) during rain events.

A vegetated area intercepts and retains a large part of the rainfall, and subsequent surface runoff from a rain event. This intercepted water has additional opportunity to evaporate or seep into the ground. In general, a smaller percentage of the rain falling on a vegetated area will enter local streams and canals as surface

runoff than a comparable urban area. As a result, stream flows in vegetated areas are moderated compared to urban areas.

**Drainage Basin** - If rains falls over a large enough area, some of the runoff from that storm will likely enter one stream, and some of it will enter another stream. It is said that those streams "drain" different basins, that they are in different "drainage basins". The drainage basin of a stream is all the land that contributes runoff to the stream or its tributaries. It is usually specified to be the land draining to the stream upstream of a given point, such as the mouth of the stream. The boundary between drainage basins is termed a "divide". Runoff is divided along the boundary, runoff on one side of the boundary flowing to one stream, and runoff on the other side of the boundary flowing to another stream.

**Water Surface Elevations** - A water surface elevation in a canal is the distance from the water's surface to some reference elevation or "datum". In the District, all elevations are relative to the National Geodetic Vertical Datum (NGVD). Water surface elevations are measured in feet (ft). Water surface elevations may also be referred to as "stages".

Important water surface elevations are the headwater (upstream) stage, and the tailwater (downstream) stage at the control structures (see **Control Structures**). The difference between these stages will affect the flow through or over the structure. Gravity flow is always from the highest to lowest elevation and, in general, flow increases as the difference in elevation increases. Note that in some basins, pumps are used to move water from lower to higher elevations.

Water surface elevations anywhere else in the canal are also important. Obviously, if the stage exceeds the elevation of the top of the canal, flooding will result. Not as obvious is the fact that the stage in the canal largely determines the water table elevation of the local groundwater (see **Runoff and Drainage**). The stage in the lower reaches (near the ocean) in some canals is maintained at levels high enough to prevent intrusions of saltwater into the local groundwater. In other areas, stages are maintained that keep water table elevations low enough to prevent drainage problems in low lying areas.

**Control Structures** - The structures referred to in the basin descriptions are devices (e.g., weirs, spillways, and culverts) placed in the canals to control water surface elevations (stage divide), amount of flow (stage divide or water supply structure), or direction of flow (divide structure) in the canals. A structure may have more than one function. In general, a stage divide controls water surface elevation upstream of the structure, and it controls water flow (or discharge) downstream of the structure. A divide structure is usually located at or near a basin boundary. It prevents water in one basin from entering the other basin. A water supply structure is also usually located near a basin boundary. It is used to pass water from one canal to another (i.e., from one basin to another).

**Hydraulic Analysis** - A set of water surface elevations taken along the length of a canal is known as the hydraulic profile of the canal. The elevations always increase upstream. This, in the simplest sense, says that water runs downhill, but is has more important implications for design of canals and structures. The water surface elevations are a function of the size and shape of the canal, the amount and location of inflow to the canal, the roughness and slope of the canal, and the downstream water surface elevation of the canal (often determined by some control structure). Canals are designed to pass a certain amount of flow without

over-topping their banks. Designing a canal and its structures consists of selecting values for the factors listed above for which none of the water surface elevations of the resulting hydraulic profile exceed the elevation of the banks of the canal for the design discharge. Since the design discharge is given, and to a large extent the slope of the canal is determined by the topography of the basin, it is the size and shape of the canal, and the downstream water surface elevation (to be maintained by some structure), that are varied to achieve a successful design. (The downstream structure must also be large enough to pass the design discharge.) Because the factors that determine the water surface elevations are either known or can be reasonably estimated, it is possible to calculate the hydraulic profile of a proposed canal design. In this way an appropriate design can be selected. Similarly, calculation of the hydraulic profile, can be used to determine the flood protection provided by a canal constructed without regard to a specific design storm, or for a canal that has been modified with regard to its design specifications. For example, increasing the cross-sectional area of a canal will, in general, allow the canal to pass a given flow at stages lower than before enlargement (i.e., the hydraulic profile is lowered). Hydraulic analysis may determine for this canal that the flood protection has increased, that is, the canal can now pass the runoff from a storm more severe than the design storm.

**Design Storm** - The design storm for a basin is the most severe storm for which the canals and structures in the basin will accommodate that storm's runoff without flooding occurring in the basin. Sometimes a basin is described as having "flood protection" up to a certain design storm.

A severe storm is described by the frequency with which it may occur. On a long term average a storm of given intensity may occur, for example, once in every ten years (i.e., the storm has a ten percent chance of occurring in any given year). This is written as 1-10 years, and is read as one in ten years. It must be emphasized, however, that a storm of a given intensity can occur at any time regardless of the frequency assigned to it. For example, two severe storms, of an intensity that occurs on average only once in every one hundred years (1-100 year storm), occurred in northern Palm Beach County within three months of each other in the early 1980s.

The Army Corps of Engineers specifies a Standard Project Storm (SPS) for south Florida. The rainfall amounts for the SPS are those for a 1-100 year storm increased by 25 percent. The storm is assumed to occur during the hurricane, or wet season, when water tables are high and soils are wet. These conditions will maximize the runoff from the storm. The runoff from the SPS is designated the Standard Project Flood (SPF). The capacity of a canal and its structures may be given as a percentage of the SPF (e.g., 40 percent SPF). The storm that would generate this amount of runoff is given by its recurrence interval (e.g., 1-10 years). Note that it is implicitly assumed that these storms occur for antecedent weather conditions that will maximize the runoff from the storm in the basin of interest.

A severe storm of a certain frequency may not generate the same amount of runoff in different basins of the same size even when antecedent weather conditions or water table elevations for the basins are similar. Land use in the basins will also affect the relative amounts of surface runoff to be expected from the basins (see **Runoff and Drainage**). Urban areas will have relatively more surface runoff than will more vegetated areas.

The amount of runoff to be expected per unit area for design storms at various recurrence intervals, antecedent conditions, and land use can be found in the Army

Corps of Engineers' General Design Memorandum (GDM) for the Project. The runoff calculated to occur for a given set of storm frequency, antecedent conditions, and land use is the design discharge. It should be noted that land use in Broward County has changed considerably since the GDM was written.

## APPENDIX 2 - GLOSSARY

### Designations Given to District Works

**C-XXX** The letter C followed by a number, designates a Central and Southern Florida Flood Control Project canal. For example, C-11 reads as "Canal 11".

**G-XXX** The letter G followed by a number, designates a Central and Southern Florida Flood Control Project structure (see Control Structures, under Basic Concepts). For example, G-72 reads as "Control Structure 72". G structures were built by the District.

**L-XXX** The letter L followed by a number, designates a Central and Southern Florida Flood Control Project levee. For example, L-38E reads as "Levee 38 east".

**S-XXX** The letter S followed by a number, designates a Central and Southern Florida Flood Control Project control structure (see Control Structures, under Basic Concepts). For example, S-26 reads as "Control Structure 26". S structures were built by the U.S. Army Corps of Engineers.

### Terms

**Area A and Area B**

These are areas of relatively good and relatively poor drainage, respectively, in north-central Broward County and in south-central Broward County. In Broward County, Area B is approximately bounded on the north by the Hollywood Boulevard, on the south by the Dade-Broward County line, on the west by L-33, and on the east by the Flamingo Road. Land elevations in this area are low relative to the coastal ridge in eastern Broward County. Consequently drainage from this area is poor, and the area is prone to flooding. Severe limitations are placed on land use and development in Area B. Only the C-9 basin in Broward County includes portions of Area B. This is noted in the text and on the maps where it occurs. Area A is better drained and less likely to flood. In Broward County it includes all lands excluding Area B and the Water Conservation Areas. Restrictions on land use and development are less severe than for Area B.

**District**

This refers to the South Florida Water Management District (formerly the Central and South Florida Flood Control District), the agency which operates and maintains the Project.

**Free Digging Contract**

This refers to an agreement between the District and an outside party whereby that party excavates a canal (or a portion of a canal). The outside party receives the excavated material as payment for the excavation. The material is generally used as fill for residential and commercial developement.

**General Design Memorandums**

This is a document prepared by the U.S. Army Corps of Engineers that reports all work done preliminary to preparation of the final design of a project. In the General Design Memorandum for the Central and Southern Florida Flood Control Project:

- the basins are delineated.
- a design storm is specified and the resulting runoff is estimated for each basin.
- the flood protection to be afforded each basin is identified.
- the size of canals, and the size and number of control structure is determined.

The final design of the canals and structures is given in the Detailed Design Memorandum.

**1-XXX Year**

This designates the recurrence interval for a design storm (see **Design Storm**, under **Basic Concepts**). For example, "1-100 year storm" reads as one in one-hundred year storm.

**Project** This refers to the Central and South Florida Flood Control Project. The Project has been responsible for the construction of most of the major canals and structures in south Florida.

**Regulation Schedule**

A regulation schedule specifies the level of water to be held in a reservoir (e.g., a WCA) as a function of the time of year.

**Regulatory Release**

A regulatory release is water discharged from a reservoir (e.g., a WCA) to lower the water level in the reservoir to the regulation schedule.

**Water Conservation Areas**

The five Water Conservation Areas (WCAs 1, 2A, 2B, 3A, and 3B) are located in western Broward and Dade Counties and in central Palm Beach County. WCAs 2A, 2B, 3A, and 3B border on basins described in this publication (Figure 1). The WCAs are remnants of the original everglades in South Florida. Water is impounded in the WCAs by Project levees, and water flow into and out of the WCAs is regulated by various Project control structures. The WCAs are managed to store water and to provide viable wetlands habitat. Water is stored in the WCAs according to a set of regulation schedules, one for each WCA. A regulation schedule specifies the level of water to be held in the WCA at any time during the year. When the water level in a WCA exceeds its schedule, water is released from the WCA through the structures on its periphery. These are called regulatory releases. If the water level in a WCA is below the regulation schedule, releases from the WCA are restricted. During periods of low natural flow, water stored in the WCAs can be supplied to basins in Broward County.

## Abbreviations

**cfs :** cubic feet per second

**ft :** Feet

**GDM :** General Design Memorandum

**NGVD :** National Geodetic Datum (see **Control Structures**, under **Basic Concepts**)

**SPF :** Standard Project Flood (see **Design Storm**, under **Basic Concepts**)

**SPS :** Standard Project Storm (see **Design Storm**,under **Basic Concepts**)

**WCA :** Water Conservation Area